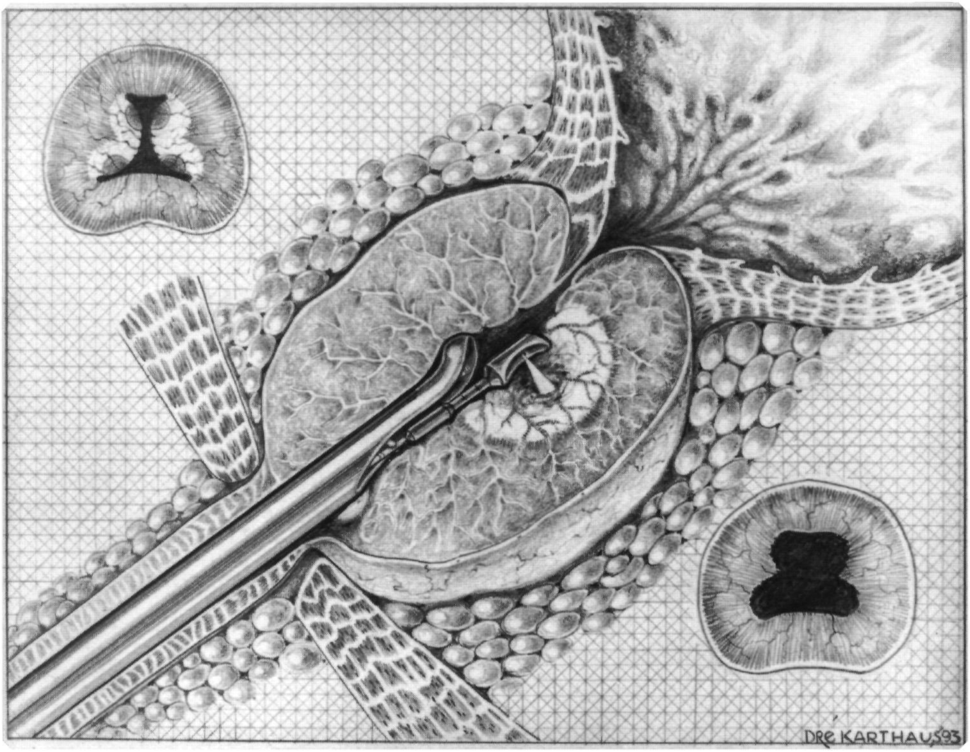

DRE KARTHAUS 93

Laser prostatectomy in the treatment of benign prostatic obstruction

Laser prostatectomy in the treatment of benign prostatic obstruction

Een wetenschappelijke proeve op het gebied van de
Medische Wetenschappen

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
Katholieke Universiteit Nijmegen,
volgens besluit van het College van Decanen
in het openbaar te verdedigen op
dinsdag 27 mei 1997,
des namiddags om 1.30 uur precies

door

Eduard te Slaa
geboren op 10 november 1959 te 's-Gravenhage

Thesis approved by:

Promoter	Prof. Dr. F.M.J. Debruyne
Co-promoter	Dr. J.J.M.C.H. de la Rosette
Manuscriptcommissie	Prof. Dr. Th. Wobbes, voorzitter
	Prof. Dr. A. Deutman
	Prof. Dr. J.M.W.M. Merkus

Laser prostatectomy in the treatment of benign prostatic obstruction / Eduard te Slaa

Proefschrift Katholieke Universiteit Nijmegen. - Met lit. opg.
ISBN: 90-9010565-4

Print: Benda Drukkers, Nijmegen
Cover: Dr. A.J.M. Karthaus

The publication of this thesis was generously supported by Bard, Benelux n.v.

Additional financial support was granted by: Abbott bv, Bayer bv, Byk Nederland bv, Christiaens bv, Hoechst Marion Roussel bv, Hoogland Medical bv, Huikeshoven medical bv, Lorex Synthélabo bv, Medical Measurements Systems, Merck Sharp & Dohme bv, Olland bv, Schering-Plough bv, Stichting Urologie 1973, Storz Endoscopy Nederland bv, Yamanouchi Pharma bv, Zeneca Farma.

Ter nagedachtenis aan mijn ouders

Contents **Page**

Chapter 1

Introduction and Outline of thesis

Introduction

Benign prostatic hyperplasia (BPH) resulting in bladder outlet obstruction is one of the most significant problems affecting men today. Approximately 90 % of men will have histologic evidence of BPH by age 90.[1] This non malignant enlargement of the prostate may lead in most men aged over 50, to troublesome lower urinary tract symptoms (LUTS) and about 25 % of all men will undergo prostatectomy by the eight decade of life.[2]

For already more than 60 years transurethral resection of the prostate (TURP) is the "golden standard" in the treatment of bladder outlet obstruction. Although this procedure has a high success rate, 20-25% of patients do not have satisfactory long term outcome and there is a reoperation rate of up to 15% over an 8 year observation period.[3,4] Furthermore, despite a reduction in mortality rate from 2,5% to 0,2% over the last 25 years, morbidity remained relatively constant at 18% in the first 90 days after TURP.[5] Adverse experiences secondary to TURP are well-known. These include bladder neck contracture (2,8%) and urethral stricture (0,6%-6,3%), incontinence (0,2%-19%) and erectile dysfunction (0%-40%). Retrograde ejaculation is essentially expected after TURP (55%-90%). Complication of a more severe nature including the "TUR-syndrome"(0,8-1,5%), cardiac dysfunction (2%) and blood transfusion (2,5%-14%) continue to be a result of this procedure.[2,5,6]

For these reasons and also because of the high costs induced by the treatment of BPH for the National Health Care systems, which will be higher in the near future due to ageing of the population, investigators began to look for alternative means of therapy to treat bladder outlet obstruction. As a result numerous new therapies have emerged, including medical management directed toward either relaxing the prostate smooth muscle (alpha-receptor blockade)[7,8] or shrinking the prostate adenoma (5 alpha-reductase inhibitors)[9], and several minimal invasive procedures with the intention to remove prostatic tissue.[10-14] Balloondilatation of the prostatic urethra or placing of stents have either been abandoned, or reserved for the unfit patient.[15,16]

The development of new minimal invasive therapies today is based on producing enough heat into the prostate to cause thermal damage of the tissue and thereby creating a prostatic cavity. Different sources are used, varying from high intensity focused ultrasound to microwaves, radiofrequency and laserlight.

Laser

The word "laser" is an acronym for "Light Amplification by the Stimulated Emission of Radiation". As recently as 1960, Maiman generated the first beam of laser light.[17] Three properties make the laser unique. First, the light is monochromatic and as opposed to natural light sources, which are emitting light over the entire visible spectrum, the laser emits light over a very narrow, well-defined wavelength. Second, laser light is coherent, which means that each peak, and valley of the sine wave curves align exactly; thus laser light is perfectly in phase in contrast to normal light, which is non coherent. Finally, the laser beam is non divergent, whereas normal light radiates in all directions. Because of these properties laser light is very suitable for transportation of energy over a great distance.

Tissue effects

The principle which determines the tissue effects and, therefore the therapeutic potential of a laser, is the thermal transformation of the light energy. Laser interacts with tissue in four ways:

- Absorption, which is essential for conversion of light energy into thermal energy
- Reflection; the light is reflected away from the tissue surface.
- Scattering; the light is reflected internally by various tissue components and thus resulting in a more diffuse absorption.
- Transmission, which means penetration of light through the tissue, and

therefore the greater the transmission the lower the absorption and the less energy is transferred to the tissue.

The absorption of the laser light, and as a result the development of thermal energy and/or damage, by the tissue is determined by the wavelength of the laser light, the colour of the tissue and other tissue characteristics. In addition, the power density of a laser has important implications regarding the tissue effects and depth of penetration. Power density is the result of power output of the laser source, the transmission of the fiber and the irradiated surface area (spot size), defined by the characteristics of the fiber used and its distance to the tissue.[18] As power density increases, the temperature of the irradiated area rises.

With laser prostatectomy, removal of abundant tissue is possibly the key mechanism. In case of laser irradiation, tissue removal can be obtained in two different ways: indirectly by heating of the tissue to a maximum of 100°C thus causing the coagulated tissue to slough and/or absorb after the procedure, or instantaneously by vaporising the tissue while temperatures rise over 300°C. Either way depends on the power density at the tissue surface in combination with the irradiation time.

The most commonly used laser in urology is the Nd:YAG laser, which is composed of neodymium ions in a Yttrium-aluminum-garnet lattice and emits light with a wavelength of 1064 nm. Light at this wavelength is poorly absorbed by water and haemoglobin allowing transmission through irrigation solutions commonly used during transurethral procedures. Another characteristic of Nd:YAG laser light, making it very useful in urology, is the possibility of transmission by fiber optics through small quartz fibers, which are easily passed through standard cystoscopes.

Type of laser applications

There are four types of fiber systems that have been used to treat the prostate: bare fibers, right angle fibers, contact tips and interstitial fibers.

In the past bare fibers were used by Kandel[19] to treat the prostate in a canine model and by Shanberg[20] who performed transurethral incision of the prostate in men. Both found this to be a slow procedure and Shanberg described a significant incidence of postoperative bleeding.

One of the first side firing devices developed to apply laser energy to the prostate was the TULIP (transurethral ultrasound-guided laser-induced prostatectomy) system. The TULIP system combines a real-time ultrasound transducer and a Nd:YAG laser delivery system within a 20 French transurethral probe. Treatment is done under ultrasound guidance. The laser light is delivered through a prism within the device which deflects the beam from a standard laser fiber at 90° from the probe toward the tissue. The distal end of the probe is covered by a special sterile sleeve at the end of which is an encompassing balloon (36 or 48 Fr.). The disadvantages are that it precludes the use of direct vision, the technique has a long learning curve, and the equipment is very expensive.

Free beam, side firing devices, for example the Urolase, the Prolase, and the Ultraline have the advantage of direct cystoscopic control. These fibers differ in mechanism and angle of beam deflection, beam profile and spot size. Depending on those beam characteristics and the distance of the fiber to the prostatic surface, either coagulation or vaporisation can be created. Most of these fibers can be passed through a standard 23 French cystoscope. All of these fibers have their own treatment protocol, which vary in power setting (amount of Joules and time per application) and the place or technique of laserapplications.

Contact tips were developed to achieve such a high power density which would result in direct vaporisation of the tissue and therefore creating immediately a prostatic cavity. The contact tip may be coated with an infrared absorber, or it may become slightly coated with carbon after contact with the tissue. This increases the absorption of laser light at the fibertip and as a result induces high temperatures at the prostatic surface resulting in vaporisation. Experiences with this system up to now has learned that this

procedure is slow and tedious, especially in larger prostates.
Interstitial application of laser energy delivers heat directly into the prostate rather than from an adjacent position. A laser fiber with a tip which produces a diffuse or a conical beam, is passed through a standard cystoscope and placed interstitially within the prostate to cause multiple areas of coagulation necrosis. Potential advantages of this procedure seems to be the fact that the urothelium of the prostatic urethra remains intact and consequently no sloughing of tissue develops, thus avoiding postoperative problems as irritative voiding complaints. The necrotic tissue will be resorbed in time, leading to an atrophic, shrunken prostate gland. Disadvantages are the learning curve and less visual control of laser energy effect.

Outline of thesis

When using a free beam side firing laser device there will be loss of laser energy due to transmission of the laser light through the fiber and also because of absorption of laser energy at the coupling between the end of the fiber to the device which reflects the laserbeam. During a laser prostatectomy this loss of laser energy will increase due to contamination or even damage of the fibertip. In the first part of **chapter 2** the results of transmission measurements in a laboratory setting and visual inspection of two types of laser fibers after a laser prostatectomy are described. In the second part transmission measurements were performed in eight types of laser fibers before use, and in three types of fibers before and after a laser prostatectomy. Transmission measurements were performed with a power meter (Aquarius), developed in the Medical Laser Center, University Hospital Utrecht, which can perform transmission measurements under clinical conditions, that is, under water and at a relatively high power input. The influence of the decay of laser fibers during laser prostatectomy is presented in the last part. The transmission measurements described in the second part are correlated with the clinical outcome parameters of the laser prostatectomies
In the first part of **chapter 3** the results of a prospective study comparing the

clinical outcome parameters after laser prostatectomy with two different types of laser fibers are presented. The second part presents the results of a Dutch multicenter study to investigate the inter-operator variability. In 5 different centers laser prostatectomies were performed with the same type of laser fiber. A total of 233 patients were included.

Pressure/flow study analysis is considered to be the "gold standard" to objectively determine the grade of bladder outlet obstruction. The first part of **chapter 4** describes a prospective study of advanced urodynamics with pressure-flow analysis in forty patients before and 6 months after laser prostatectomy with three different types of laser fibers. The second part presents the result of a prospective study of pressure-flow analysis in 79 patients before and after laser treatment. Two different types of laserfibers were used. In this study a comparison was made between patients who were minimally obstructed and patients who were severely obstructed before laser prostatectomy.

One of the major reasons for the development of alternative treatments for TURP is the high morbidity rate of this procedure. The first part of **chapter 5** presents the results of the incidence of urinary tract infections following laser prostatectomy. The influence of antibiotic prophylaxis was also studied. A total of 116 patients was evaluated of which 73 patients received antibiotics. The second part presents the results of the assessment of quality of life before and after laser prostatectomy in 103 patients. Correlations between objective outcome parameters and symptom scores on one hand and quality of life assessment on the other are also presented.

Finally, in **chapter 6 a** review of lasers in benign prostatic obstruction is presented ending with future perspectives.

References

1. Berry SJ, Coffey DS, Walsh PC, Ewing LL. The development of human prostatic hyperplasia with age. J Urol **132**: 474,1984
2. Holtgrewe HI, Mebust WK, Dowd JB, Cockett ATK, Peters PC, Proctor C. Transurethral prostatectomy: Practice aspects of the dominant operation in

American urology. J Urol **141**: 248, 1989

3. Barry MJ. Epidemiology and natural history of benign prostatic hyperplasia. Urol Slin North Am **17**: 495, 1990
4. Lepor H, Rigaud G. The efficacy of transurethral resection of the prostate in men with moderate symptoms of prostatism. J Urol **143**: 533, 1990
5. Mcbust WK, Holtgrewe HL, Cockett ATK, Peters PC and writing committee. Transurethral prostatectomy: Immediate and post-operative complications. A cooperative study of 13 participating institutions evaluating 3,885 patients. J Urol **141**: 243, 1989
6. Doll HA, Black NA, McPershon K, Flood AB, Williams GB, Smith JC. Mortality, morbidity and complications following transurethral resection of the prostate for Benign Prostatic Hyperthrophy. J Urol **147**: 1566, 1992
7. Jardin A, Bensadoun H, Delauchcavalier MC, et al. Long-term treatment of benign prostatic hyperplasia with alfuzosin: a 24-30 month survey. Br J Urol **74**: 579, 1994
8. Lepor, H. Long term efficacy and safety of terazosin in patients with benign prostatic hyperplasia. Urology **45**: 406, 1994
9. Stoner, E. Three year safety and efficacy data on the use of finasteride in the treatment of benign prostatic hyperplasia. Urology, **43**: 284, 1994
10. Cowles III RS, Kabalin JN, Childs S, Lepor H, Dixon C, Stein B, Zabbo A. A prospective randomized comparison of transurethral resection to visual laser ablation of the prostate for the treatment of benign prostatic hyperplasia. Urology **46**: 155, 1995
11. Madersbacher S, Kratzik C, Szabo N, Susani M, Vingers L, Marberger M. Tissue ablation in benign prostatic hyperplasia with high intensity focused ultrasound. Eur Urol **23** (suppl 1): 39, 1993
12. Schulman CC, Zlotta AR, Rasor JS, Hourriez L, Noel JC, Edwards SD. Transurethral needle ablation (TUNA): Safety, feasability and tolerance of a new office procedure for treatment of benign prostatic hyperplasia. Eur Urol **24**: 415, 1993
13. Servadio C. Ten years of clinical experience in transurethral hyperthermia to the prostate. In "Non-surgical treatment of BPH. SIU report 3". Editor Fitzpatrick JM, Churchill-Livingstone, Edinburgh: 175-186, 1992
14. Devonec M, Berger N, Perrin P. Transurethral microwave heating of the prostate or from hyperthermia to thermotherapy. J Endourol **5**: 129, 1991
15. Lepor H, Sypherd D, Machi G et al. Randomized double-blind study comparing the effectiveness of balloon dilatation of the prostate and cystoscopy for the treatment of symptomatic benign prostatic hyperplasia. J Urol **147** : 639, 1992
16. Milroy EJG. Prostatic stents. Current Opinion in Urology, 5: 25, 1995
17. Maiman TH. Stimulated optical radiation in ruby. Nature **187**: 493, 1960

18. Van Swol CFP, Verdaasdonk RM, Mooibroek J, Lock MTWT, Boon TA: Prediction of the necrotic zone depending on the optical and thermal characteristics of laser prostatectomy modalities. J Urol **151**: 419A, 1994

19. Kandel LB, Harrison LH, McCullough DL, Woodruff RD, Dyer RD. Trans-urethral laser prostatectomy: creation of a technique for using the Neodymium:Yttrium Aluminium Garnet (YAG) laser in the canine model. J Urol **135**:110A, 1986

20. Shanberg AM, Tansey LA, Baghdassarian R. The use of the neodymium YAG laser prostatectomy. J. Urol **133:** 331A, 1985

Chapter 2

Durability of laser fibers

Based on:

E. te Slaa, A.F. van Ettergem, C.A. van 't Hof, F.M.J. Debruyne, and J.J.M.C.H. de la Rosette.

*Durability of laser fibers. World J Urol **13**: 83, 1995*

C.F.P. van Swol, E. te Slaa, R.M. Verdaasdonk, J.J.M.C.H. de la Rosette, and T.A. Boon.

*Variation in output power of laser prostatectomy fibers: A need for power measurements. Urol **47**: 672, 1996*

E. te Slaa, C.F.P. van Swol, T.A. Boon, R.M. Verdaasdonk, W.H. Doesburg, F.M.J. Debruyne, J.J.M.C.H. de la Rosette.

The influence of the decay of laser fibers during laser prostatectomy on the clinical results. Submitted

Durability of laser fibers

World J Urol **13**: 83, 1995

Abstract

In 90 patients treated with laser prostatectomy, using the Urolase (n=50) or Ultraline (n=40) laserfiber, the fiber tip durability was investigated. In general the Urolase fiber tips were less damaged than the Ultraline fiber tips. At visual inspection, 62% of the Urolase fiber tips were graded as minimally damaged in comparison with 28% of the Ultraline group. The Urolase fiber tips are more susceptible than the Ultraline fiber tips to damage caused by tissue contact, whereas the latter seems more fragile. Transmission measurements were performed in a laboratory setting to estimate the loss of energy output at the fiber tip due to damage. These measurements showed a major loss in almost all fibers. None of the Ultraline fibers had less than 10% transmission loss, and 18% of the Urolase fibers had a transmission value of more than 90%. Finally there seemed to be a poor correlation between the visual aspects of the fibers used and the changes in transmission.

Introduction

Benign prostatic hyperplasia (BPH) has a high prevalence in men over 50 years of age. Almost 50% of men with macroscopic BPH will develop voiding complaints, and the majority of these men will eventually require surgery.[1]

For more than 60 years, the "gold standard" of surgical therapy for this problem has been transurethral electroresection of the prostate (TURP). Although the mortality has been reduced from 2.5% to 0.2% over the past 25 years, the morbidity has remained unchanged at 18%.[2] Because of this rather high morbidity, many (minimally invasive) alternative treatment methods were introduced during the last decade, such as medical management, balloon dilatation, prostatic stents, hyperthermia, and thermotherapy. Although the morbidity has decreased, these alternatives have not been capable of replacing TURP because none of these methods has thus far reached the same results as TURP.

Following the canine feasibility studies of Johnson et al.[3] in 1991 and the first laserprostatectomies performed with a sidefiring device in men by Costello et al.[4] in 1992, the laser was introduced for the treatment of symptomatic BPH. Recent reports show that the results after laser prostatectomy are comparable with those achieved after TURP.[5-9] However, laser treatment also has its limitations. Except for the contact devices currently under investigation, during the procedure the amount of tissue destruction cannot be controlled accurately by the surgeon. A factor associated with tissue destruction is the amount of energy delivered to the prostate that will eventually be absorbed by the prostate gland. This depends on a number of variables, such as reflection of laser light, changes in tissue characteristics during lasing, tissue cooling via increased prostatic blood flow, the colour of the prostate, and loss of power output due to fiber tip decrease during the laser procedure. The present study was performed to investigate the posttreatment decrease in the quality of the laser fibers currently used at our department.

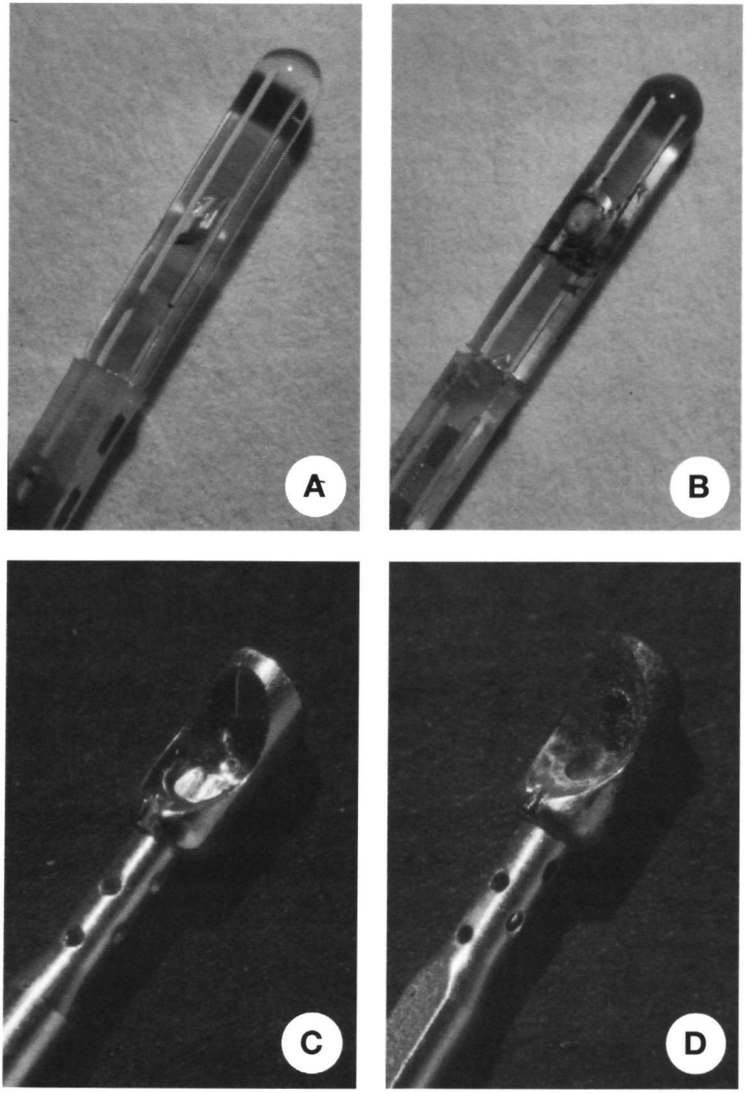


Fig. 1 *Visual aspects of the laser fibers.* ***a*** *New Ultraline fiber.* ***b*** *Severely damaged Ultraline fiber.* **c** *New Urolase fiber.* **d** *Severely damaged Urolase fiber.*

Material and Methods

Laser prostatectomy was performed with the Urolase or Ultraline fiber. The techniques used have been described extensively in an article by de la Rosette et al..[10] After the treatment, the energy delivered by the laser source was noted, and the laser fibers were cleaned with a swab and sterile water.

To asses the effect of laser prostatectomy on the quality of laser fibers we visually examined the fibers used. The fiber tips were independently inspected by two observers involved in the performance of the laser treatment, who graded the fiber tips on a scale ranging from 1 to 5 according to the degree of damage to the fibertip (1= undamaged, 5=severely damaged; Fig. 1). The grades given by the two observers were added up and the result was considered the score for a particular fiber. Transmission measurements to assess the percentage of energy loss were performed in a laboratory setting developed by the Department of Physics. The setting consisted of a power source, a LED (light emitting diode), producing light with a wavelength near

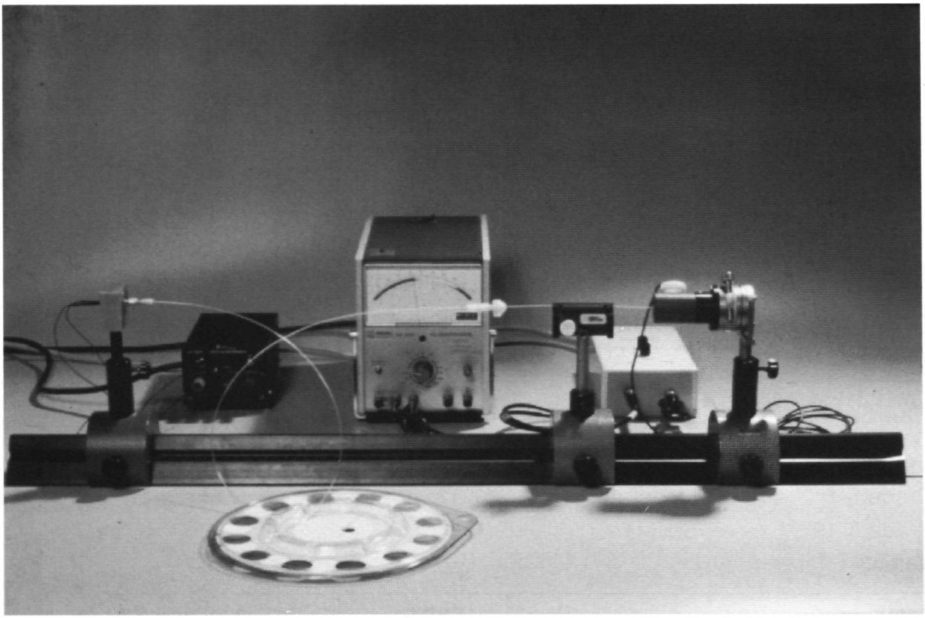


Fig. 2 *Laboratory setting used to perform the transmission measurements*

that of Nd:YAG laserlight; a coupling device to connect the fiber; an especially developed cylinder in which the fiber tip just fits; an electric eye in the cylinder connected to a power meter to measure the output from the fiber tip (Fig. 2).

Each fiber was connected to the power source and the fiber tip was then introduced into the cylinder. The electronic eye in the cylinder was situated close to the fiber tip for optimal registration of the fiber output. The fiber was manipulated by hand to produce the position with the maximum power output. The energy input was set at 5 mW. We first performed the measurements on new fibers and these results were used as baseline values. Thus, the transmission measured in used fibers are expressed as a percentage of that noted in a new fiber. These measurements were also done independently by the two investigators.

Results

Visual aspects

The Urolase fiber tips were less affected than the Ultraline fibers tips. In the Urolase group, 31 fibers (62%) were graded as minimally damaged in comparison with fibers (28%) in the Ultraline group. Moreover, the Ultraline fibers appeared to be more fragile; 9 of the 40 fibers were broken at the tip during or after the laserprocedure. On the other hand, 6 Urolase fibers (12%)

Table 1. *Presentation of the visual aspects of the laser fibers used versus the number of fibers in each subgroup*

Fibertip	Damage	Urolase (n = 50)	Ultraline (n = 40)
Grade 2-4	None-minimal	31	11
Grade 5-7	Moderate	13	18
Grade 8-10	Severe	6	2
Defect		0	9
Same grade		38/50	24/31

were severely damaged, frequently due to direct contact with the prostate tissue resulting in burning of the fiber tip. Severe damage was found in only 2 Ultraline fibers (5%). The majority of the fibers showed the same result at inspection by the two investigators (Table 1).

Transmission measurements

Overall the Urolase fibers had less transmission loss than the Ultraline fibers (Table 2). None of the Ultraline fibers had less than 10% transmission loss, whereas 9 of the 50 Urolase fibers (18%) had a transmission value of more than 90%. Only in 5 Ultraline fibers (13%) was the transmission above 80% as compared to 20 Urolase fibers (40%).

Table 2. *Presentation of the loss of transmission and the number of patients in each group*

% Transmission	Urolase (n)	Ultraline (n)
> 90	9	0
> 80	20	5
> 70	27	9
> 60	36	16
> 50	38	24

For both fibers we could not find a relation between the amount of energy delivered through the fiber and the loss of transmission (Fig. 3, 4). On average 50-60 kJ was delivered to the prostate, resulting in a transmission of 60%-70% at the end of treatment, depending on the type of fiber used.

There seemed to be a correlation between the visual aspect of the Urolase fiber tip and the loss of transmission, but the variation is too great for conclusions to be drawn for a given single fiber. A similar correlation for the Ultraline fibers was not detected. The majority of the Ultraline fiber tips showed moderate damage that did not seem to be correlated to the level of transmission (Fig. 5, 6).

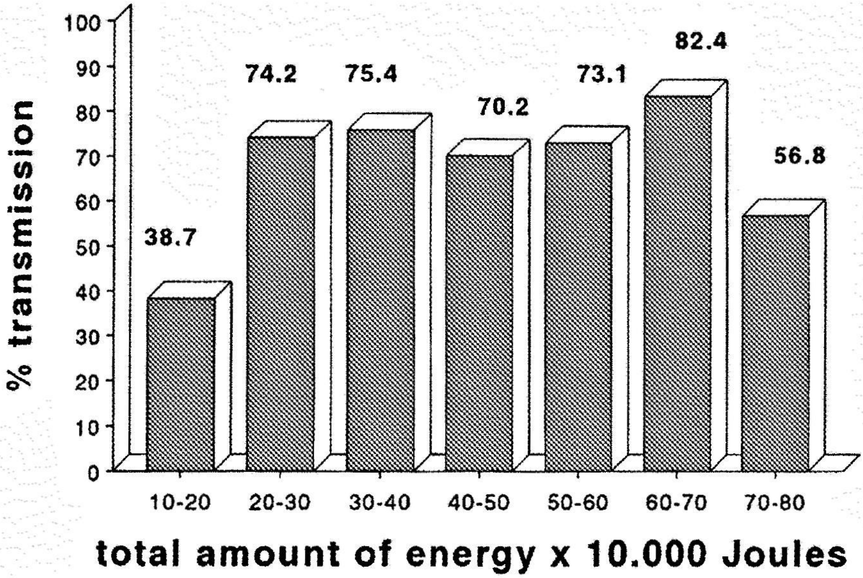


Fig. 3 *The relation between the amount of energy delivered and the loss of transmission for the Urolase fiber.*

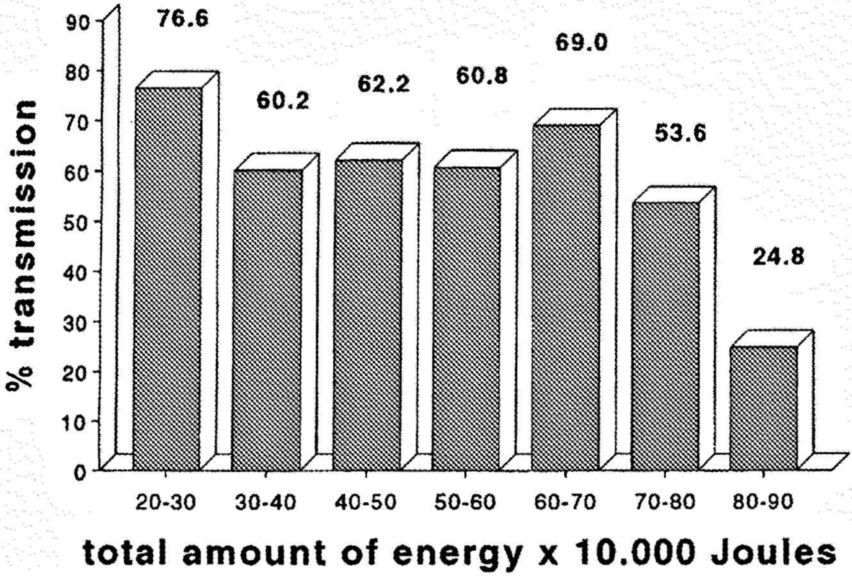


Fig. 4 *The relation between the amount of energy delivered and the loss of transmission for the Ultraline fiber*

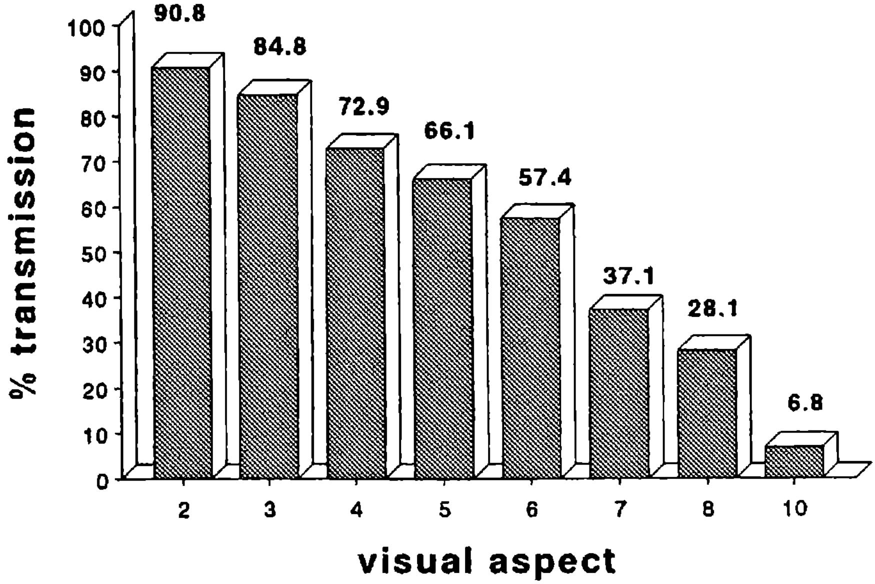


Fig. 5 *The relation between visual aspects of the Urolase fiber and the loss of transmission*

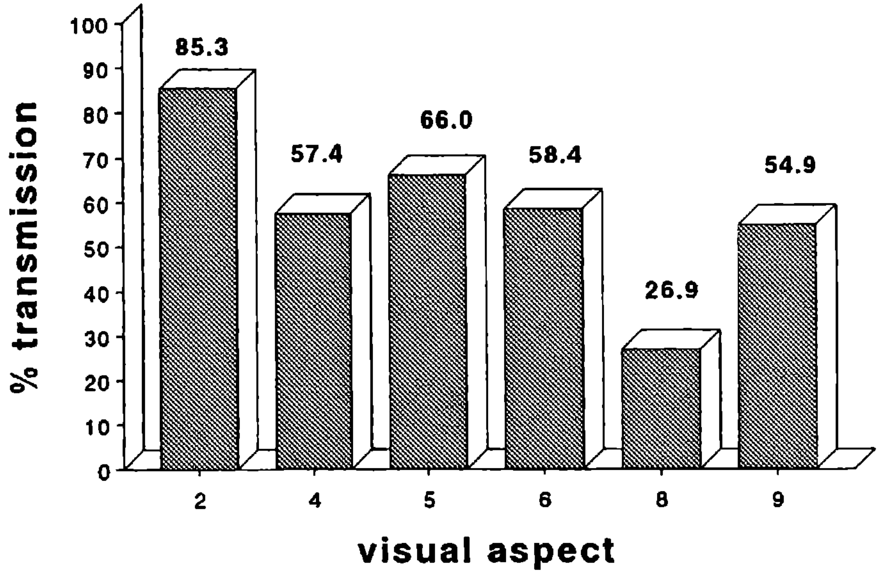


Fig. 6 *The relation between visual aspects of the Ultraline fiber and the loss of transmission*

Discussion

The Nd:YAG laser achieves the deepest tissue penetration of all available surgical lasers, and its energy is selectively absorbed by tissue proteins, causing deep thermal necrosis and resulting in tissue ablation. It is only natural, then, that use of the Nd:YAG device for laser prostatectomy should be explored.

Many different laser fibers are appearing on the market for treatment of BPH. The (non)contact laser fibers, such as the Urolase and Ultraline fiber, redirect the beam laterally so as to allow better tissue ablation. However, there is no reason to assume that these fibers are equivalent. The redirecting mechanisms include highly engineered reflecting mirrors (e.g., the Urolase fiber) or quartz refractive prisms (e.g., the Ultraline fiber). The beams are deflected at various angles and the spot size differs from one fiber to the next. In the ideal setting, the amount of energy delivered to tissue is, among other factors, determined by the power setting (watts) and the length of time over which the beam is activated (seconds). The product of these two parameters is the amount of energy delivered and is measured in joules. In most situations it is impossible to determine specifically how much energy has been absorbed.

The optimal Nd:YAG power setting, time for energy delivery and type of applicator for laser treatment remain under investigation. Some power transmission is lost in the bending mechanism and this varies depending on the efficiency of the process used. The dosimetry protocols for the devices are rather similar although the devices themselves vary significantly as to the power density at the urethral wall. From studies by van Swol et al.[11] we have learned that the optical characteristics of the devices may differ significantly, mainly due to the method of beam deflection. It was concluded that besides the prostate geometry and the blood perfusion, the power density at the urethral wall should be taken into account in the dosimetry for an effective BPH treatment. Shanberg et al.[12] presented a study determining the depth of penetration of the laser in the human prostate at varying dosimetry. Using the Prolase II laser fiber, their data indicated that for this type of fiber there

appeared to be an optimal power setting and pulse duration for the greatest depth of penetration. Kabalin[9] has shown that for the Urolase fiber the 40 Watts, 90 sec. setting provides optimal results for laserprostatectomy.
However, before laser energy is applied to the prostate, it must be transmitted from the laser source by the laser fiber. The present study shows that a difference in transmission measurements can be found for the two fibers tested. None of the Ultraline fibers had less than 10% transmission loss, whereas almost 20% of the Urolase fibers had a transmission of over 90%. Therefore we may conclude that the Urolase fibers seem more durable than the Ultraline fibers. We were somewhat surprised by this result because we assumed that the Urolase fiber would be more fragile because contact with prostate tissue easily damages this device. On the other hand the observed damage to the Ultraline fibers may be explained by the observation that this fiber was also used in contact. This may eventually result in growth of particles on the fiber tip, causing a decrease in these laser fibers. The effect of this process is difficult to judge in terms of the quality of the laser fiber posttreament. The correlation between the visual aspect of the Ultraline fiber tip and the transmission was poor. In contrast with these findings were the results obtained in the Urolase group. There appeared to be a good correlation between the visual aspect of the Urolase fiber tip and the loss of transmission. Consequently one may decide to use a second fiber if the visual aspect of the Urolase fiber looks poor, whereas it is more difficult to judge the quality of the Ultraline fiber. Moreover, we must stress that a normal visual aspect of the fibertip of a given fiber does not guarantee that the quality of the fiber is good. Therefore, it may be important to measure loss of transmission during laser treatment.
The system described in the present study was used with a low power input. We realise that it would be ideal to perform these studies at 40 or 60 Watts, but this would make the measurements more difficult to perform. The currently used method is simple, reproducible, and easy to perform. The outcome of these measurements represents the minimal loss of transmission;

thus, at higher power settings the loss may be much greater.

Although the outcome of the transmission measurements show major differences for the two fibers used, the clinical results are more or less similar. We think that because use of the Ultraline fiber involves a higher power setting and a smaller beam, this may compensate for the loss in transmission and result in a more or less identical power density.

Thus, considering the variety of devices available at present, one would expect these to differ in terms of response and outcome. To our surprise, the results achieved with the fibers used in the present study were similar, according to a study by de la Rosette et al..[10] One may come to the conclusion that it is the general effect of laser energy on tissue that is most important rather than the device or technique used. However, the degradation of the fiber tip may not be reflected in the results achieved over the short term, but may differ significantly in the long term. Therefore, we think that efficacy studies should determine not only fiber characteristics but also fiber durability. If the fiber performance is being tested during the treatment, the investigator may decide to increase the power input or to replace the laserfiber.

Conclusion

Laser ablation of the prostate represents an exciting potential application of laser technology. The optimal technique as well as technology are clearly evolving and the efficacy of various side-firing devices for the treatment of BPH is under investigation. A difference in durability was found between the two fibers tested. Therefore future studies should consider measurement of fiber durability and correlate these findings with the outcome of treatment and long-term follow up results.

References

1. Barry MJ. Epidemiology and natural history of benign prostatic hyperplasia. Urol Clin North Am **17** (3): 495, 1990

2. Mebust WK, Holtgrewe HL, Cockett ATK, Peters PC and Writing Commitee. Transurethral prostatectomie: Immediate and postoperative complications. A cooperative study of 13 participating institutions evaluating 3,885 patients. J Urol **141**: 243, 1989
3. Johnson DE, Levinson AK, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, Wishnow KI. Transurethral laser prostatectomy using a right-angle delivery system. Lasers Urol Laparoscopy Gen Surg **1421**: 36, 1991
4. Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J. Laserablation of the prostate in patients with benign prostatic hypertrophy. Br J Urol **69**: 603, 1992
5. Leach GE, Dmochowski R, Kumaresan G, Broderick GS, Wein AJ, Cowles R, Kabalin JN, Gill HS. Visual Laser Assisted Prostatectomy (VLAP) using Urolase right angle fiber: multicenter 60 Watt protocol. J Urol **151**: 228A, 1994
6. Buckley JF, Ligam V, Paterson P (the British ELAP group). Endoscopic Laser Ablation of the Prostate gland (ELAP). J Urol **151**: 228A, 1994
7. Costello AJ, Crowe HR. A single institution experience of reflecting laser fibre prostatectomy over four years. J Urol **151**: 229A, 1994
8. Dixon C, Machi G, Theune C, Olejniczak G, Lepor H. A prospective, Double-Blind, Randomized Study Comparing the Safety, Efficacy and Cost for the Treatment of BPH. J Urol **151**: 229A, 1994
9. Kabalin JN. Laser Prostatectomy performed with a right angle firing Neodymium:YAG laser fiber at 40 Watts power setting. J Urol **150**: 95, 1993
10. de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ. Experience with the Ultraline and Urolase laser fibers: Is there any difference? World J Urol **13**: 98, 1995
11. van Swol CFP, Verdaasdonk RM, Mooibroek J, Lock TMTW, Boon TA. Prediction of the necrotic zone depending on the optical and thermal characteristics of laser prostatectomy. J Urol **151**: 332A, 1994
12. Shanberg AM, Lee IS, Tansey LA, Sawyer DE, Rodgers LW, Ahlering T. Depth of penetration of the neodymium:Yttrium-Aluminium-Garnet laser in the human prostate at various dosimetry. Urology **43**: 809, 1994

Variation in output power of laser prostatectomy fibers: A need for power measurements.

Urol **47**: 672, 1996

Summary

Objectives The aim of this study was the assessment of the quality of side-firing fibers that are being used for laser prostatectomy, either by a laser light transmission measurement or by visual inspection.

Methods A power meter ("Aquarius") was developed to measure the actual power transmitted through a side-firing fiber and delivered to the prostatic tissue. The power measurements were performed under clinical conditions, that is, under water and at relatively high input power. Furthermore, a protocol was developed for visual inspection of the fibers. Eight types of side-firing fibers were measured before use. Before and after a procedure, three fiber types were measured: Prolase II (28 samples), Ultraline (23 samples), and Urolase (44 samples). All these fibers were used in standard treatment protocols.

Results At 60 W the transmission of new fibers (not used) ranged between 49% and 83% when compared to a bare fiber. After use, a large variation was found in transmitted power between different samples of one device. A correlation with total transmitted power was not present. At higher power input, vapor bubbles are generated at the tip of the fibers. Depending on the fiber design, these bubbles have a major impact on the transmission. Only for the Urolase fiber was there a significant correlation between visual inspection and the transmission of used samples at 10, 20, and 40 W.

Conclusions The transmission strongly varies between fibers and between different samples of one fiber during clinical use. Moreover, the transmission does not correlate with visual inspection. A power measurement during a clinical treatment will contribute to a more controlled procedure and to a better comparison of clinical laser prostatectomy studies.

Introduction

The possible use of the neodymium:yttrium-aluminum-garnet laser as a minimal invasive treatment of benign prostatic hyperplasia was already reported in 1988.[1,2] The inability, however, to direct the laser light to the prostatic tissue resulted in an ineffective laser treatment. In 1990 the first canine experiments were performed using a side-firing fiber that could be inserted through a cystoscope[3] or that was incorporated in a transurethral ultrasound device.[4] In both cases the laser light was directed almost perpendicular to the prostatic tissue. These initial experiments were soon followed by other canine and later by human studies[5,6] to find the optimal laser prostate treatment that is to compete with the gold standard, transurethral resection of the prostate. Until now, however, there is no consensus regarding treatment strategy for laser prostatectomy. To achieve such consensus two questions need to be answered: How can we most effective apply laser energy to the prostate? Does the delivered energy depend on the type of device and does the energy delivery change with time?

The success of a laser prostatectomy can be defined as the relieve of symptoms, caused by obstructive prostatic tissue, by the application of laser energy with minimal complications. Removal of abundant tissue is possibly the key mechanism. In the case of laser irradiation, tissue removal can be obtained in two different ways: indirectly by heating of the tissue to a maximum of 100°C, thus causing the coagulated tissue to slough after the procedure, or instantaneously by vaporizing the tissue while temperatures rise over 300°C. Either way depends on the power density at the tissue surface in combination with the irradiation time.[7] The power density is the result of power output of the laser source and the transmission of the fiber, and the irradiated surface area (spot size), defined by the characteristics of the side-firing fiber that is used and its distance to the tissue.[8] This implies that, although using the same laser source and the same power settings, each type of fiber may deliver a different amount of energy to the tissue. Consequently, the results of different laser prostatectomy studies may not be comparable.

Presently, more than fifteen different side-firing fibers are commercially available. All are designed to deflect the laser light laterally, thus directing it to the prostatic tissue. In a previous study,[9] we showed that the method used to deflect the laser light highly influences the power density on the prostatic tissue. Two types of side-firing fibers can be distinguished, depending on the deflection method that is used: metal reflector and total internal reflector.

During a laser procedure, changes in fiber characteristics may occur, due to deterioration of parts of the fiber that transmit or reflect the laser light. Both transmission and beam characteristics may change, thus influencing the tissue effects and the clinical outcome in the long term. Therefore, clinical and experimental studies are difficult to compare with respect to (ideal) power settings, since the total amount of energy irradiating the tissue can only be estimated within limits.

Apart from laser-related parameters, the tissue composition and the blood perfusion also play an important role in laser-tissue interaction. Blood vessels will cool the tissue surface efficiently and prevent heat deposition in deeper tissue layers.[10,11] Characterization of prostatic tissue prior to treatment may result in a better understanding of the clinical results.

In this study a method will be presented to measure the transmission of a side-firing fiber under controlled conditions similar to clinical settings. Consequently, the power that actually reaches the tissues, and thus responsible for the tissue effects, can be determined. The measurements were done before and after clinical procedures, to monitor the behavior of side-firing fibers during use.

Material and Methods

Prior to clinical use, transmission measurements were performed on various samples of eight types of side-firing fibers. Three were metal reflectors: RotaLase (Xintec), SideFire (Myriadlase), and UroLase (Bard). Five were total internal reflectors: Angled Delivery Device (ADD; Laserscope), Laseguide (Laser Peripherals), ProLase II (Cytocare), SideFiber (Ceramoptec), and UltraLine (Heræus Lasersonics).

Before and after clinical application, the transmission of three types of fibers was measured: ProLase II (28 samples), UltraLine (23), and UroLase (44).

Transmission measurements

The transmission measurement in the experimental setting should be performed under conditions approaching those of the actual (clinical) laser treatment. Because the medium surrounding the device influences the way the laser light travels to the tissue, the measurement should take place under water. A measurement should include only that beam that contributes to the clinical effect. The transmission may be dependent on the power input, so a measurement needs to be performed with a power input similar to the clinical power setting. Fig. 1a is a schematic illustration of a side-firing fiber inserted in the prostatic urethra during treatment. In Fig. 1b the power meter setup is shown schematically and in Fig. 1c a photograph of the final version of the power meter, named "Aquarius", is shown.[12]

The detector head (power wizard, Synrad) is positioned behind a glass window at the outside of a water-filled container. A side-firing fiber is positioned through the fiber support in front of the window (detector). Through the use of this support, all fibers are positioned at the same distance (5 mm) to the detector. By repositioning the detector head (into another slot) the meter can be used to measure end-firing fibers as well (for reference). Parameters like distance of fiber to detector remain unchanged. It is possible to incorporate a water flush parallel with the fiber (through the support). The flow could be adjusted to a maximum of 3.0 ml/s. For each fiber sample the measurements were repeated five times.

Visual inspection

The simplest way of assessing the status of a side-firing fiber during clinical use is by direct visual inspection, as it can be done with minimal interruption

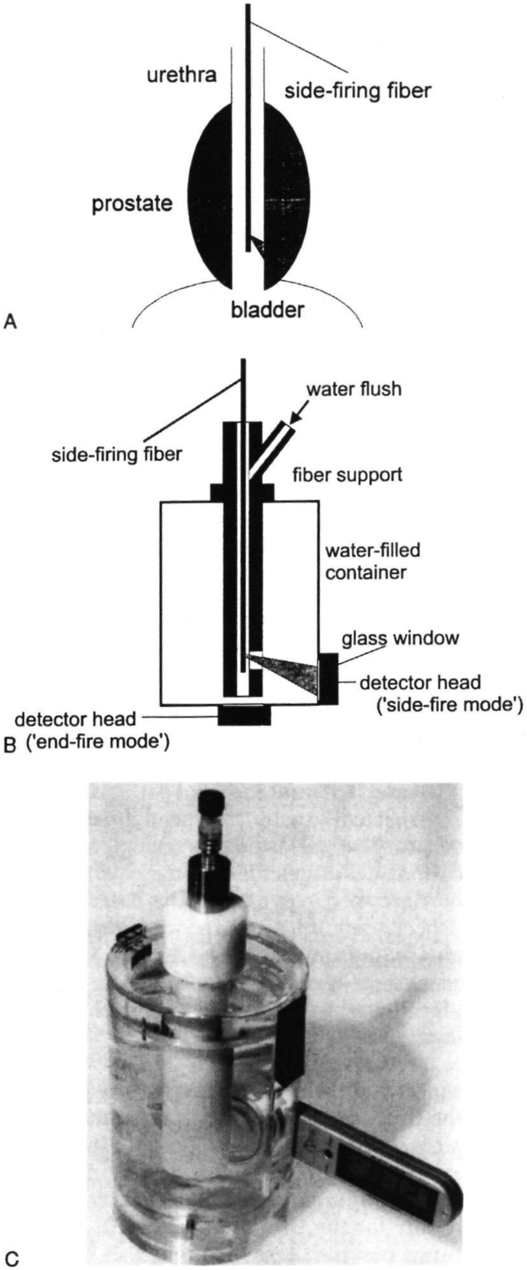


Fig. 1 *A side-firing fiber in the prostatic urethra during laser light irradiation (A) and the same side-firing fiber positioned in the experimental power meter setup (B); the final version of the setup, the Aquarius power meter (C).*

of the procedure. It is discussed whether any visual objective characteristics of a used fiber correlate to its loss in transmission of laser light. Therefore the same fibers for which the transmission was measured during clinical use were inspected visually. To obtain an objective measure a classification scheme was designed. All fibers were scored in a range from 1 to 5, where 5 is a totally damaged fiber and 1 an undamaged fiber.[13] As an example, the different grades of deterioration for the Urolase fiber are presented in Fig. 2. The fibers were evaluated by two independent observers (EtS, JdlR). The sum of the obtained scores resulted in a scale from 2 to 10.

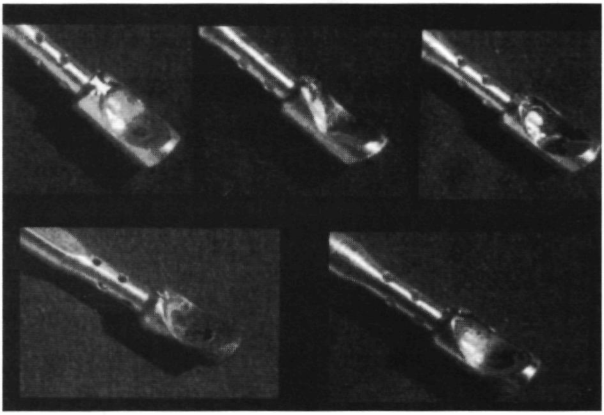


Fig. 2 *Visual aspects of the laser fiber. Example of the scoring system for the Urolase fiber. Starting from the top right corner with score 1 (undamaged), then right to left and top to bottom to the bottom left corner with score 5 (totally damaged).*

Results

New fibers

The measurements were performed at input powers of 10, 20, 40, and 60 W, using the Aquarius power meter described before. Three new fiber samples were measured for each type. The transmission was calculated relative to the transmission of a end-firing fiber with the same diameter as each side-firing fiber. The results of these transmission measurements are presented in Fig. 3. The SideFire device has the lowest transmission at 60 W, especially when compared to its transmission at lower input power. This may be caused by the presence of vapor bubbles (caused by heating of the device) near the reflecting mirror, that spreads the beam over a larger area than the detector

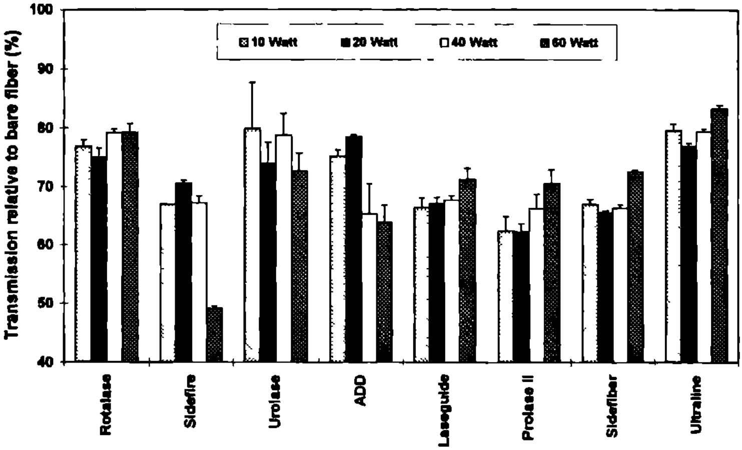
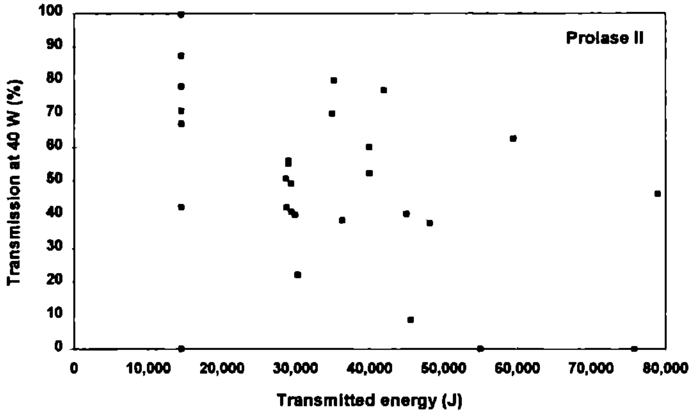


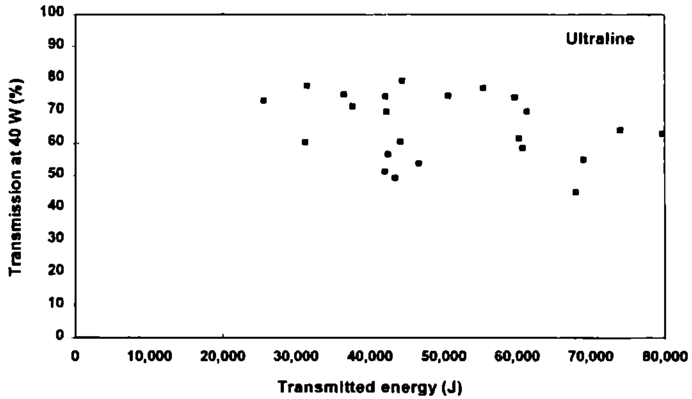
Fig. 3 *Results of the transmission measurements of eight new side-firing fibers measured with the Aquarius power meter at 10, 20, 40, and 60 W input power (bars indicate standard deviation). ADD = Angled Delivery Device.*

area. The measurements at 60 W of the other “true” reflecting type device, the Urolase, did show a large variation, probably for the same reason. Nevertheless, it is very likely that vapor bubbles are also generated with the other devices (internal reflectors) but, due to their shape, these bubbles do not stay in the laser light path.

Measurements during and after clinical use

Three different fibers, the Urolase, Ultraline, and Prolase II, were measured during and after clinical use and their transmission was compared to that before use (that is, of a new fiber). Each type of fiber was applied at its own clinical protocol. The Prolase II was used at 40 W either fixed or moved over the tissue (the "painting" method).[14] An average energy of 35,000 J was transmitted through the 28 samples. The Ultraline was used at 60 W while painting over the tissue.[15] At average a total of 51,000 J was transmitted through the 23 samples. The Urolase was used at 40 W at several fixed clock positions, depending on prostate volume.[15] The average amount of energy transmitted through the 44 Urolase fibers was 44,000 J. The measurements were performed at 10, 20, 40, and 60 W. As an example, the transmission at





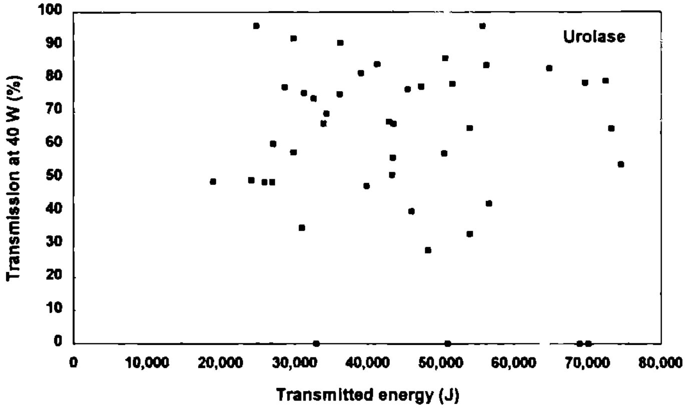


Fig. 4 *Scatter plot of the percentage transmission relative to a new fiber at 40 W of all 28 used Prolase II, 23 used Ultraline, and 44 used Urolase fibers as a function of energy transmitted*

40 W of all used Prolase II, Ultraline, and Urolase fibers is presented as a function of energy transmitted in a scatter plot in Fig. 4. The mean values and standard deviations of the transmission of the three different fiber types are presented in Fig. 5. The differences in efficiency of laser light transmission are only significant between the Ultraline and the Prolase II at 10, 20, 30, and

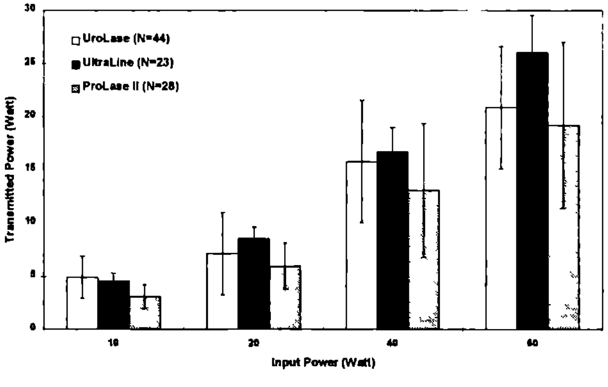


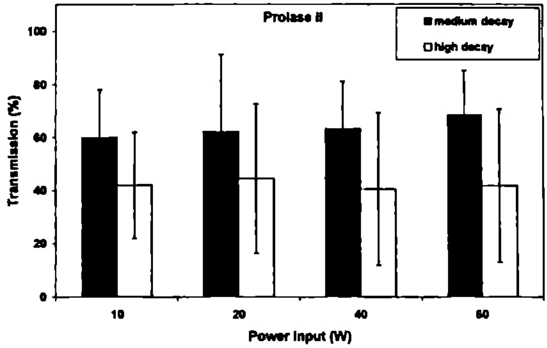
Fig. 5 *Mean power transmission of used Prolase II, Ultraline, and Urolase fibers at 10, 20, 40, and 60 W input power (bars indicate standard deviation).*

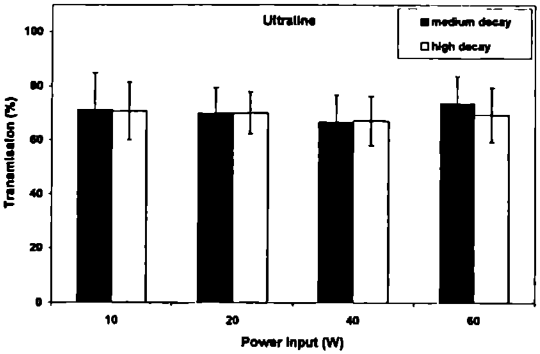
40 W, between the Urolase and the Prolase II at 10 W and the Urolase and Ultraline at 60 W (*t* test, two-tailed, $P < 0.01$). A water flush was incorporated in the measuring device with a flow rate of 3 mL/s parallel with a used side-firing fiber. The water is used normally for enhanced cooling of the fiber tip. The transmission was calculated for five used samples of the Prolase II, Ultraline, and Urolase, again at 10, 20, 40, and 60 W. Only at high power input (40 and 60 W) did the transmission increase slightly compared to the no-flush situation, as less vapor bubbles are generated at the tip. Therefore, for further experiments, the transmission measured without flush was considered similar to the situation with flush.

Visual inspection

The Prolase II, Ultraline, and Urolase were all inspected visually. The scored values (in a scale from 2 to 10) were correlated with the transmission measurements reported before. The fibers were grouped in two categories based on this visual aspect score: medium (score from 2 to 5) and high (score from 6 to 10) decay. In Figure 6 the transmission at different input powers is presented for these two categories for each of the three fibers.

Fig. 6 reveals a gross relation between the visual aspect and the transmission for the Prolase II and the Urolase fiber. For each individual sample, the correlation between the visual aspect and the transmission increased with decreasing input power. A significant statistical level could be reached only





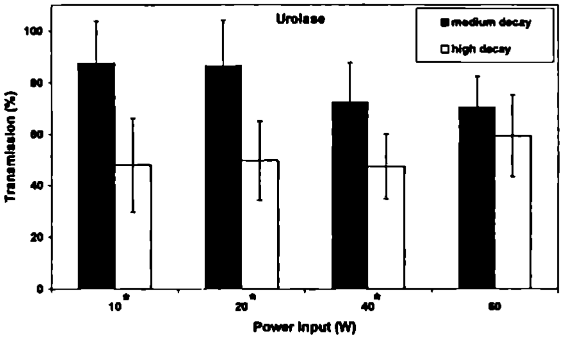


Fig. 6 *The relationship between the visual aspect (either medium or high decay) and the transmission for the Prolase II, Ultraline, and Urolase at 10, 20, 40, and 60 W input power (bars indicate standard deviation). *The difference in transmission is statistically significant, $P<0.01$.*

for the Urolase fiber at 10, 20, and 40 W input power (t test, two-tailed, $P < 0.01$). Therefore when using 40 or 60 W for a clinical treatment, visual inspection does not give sufficient information on the transmission or quality of the side-firing fibers discussed here.

Comment

Since the clinical introduction of laser prostatectomy, many side-firing fiber devices have been developed for this procedure. The results that are reported in the literature using these devices are promising regarding both objective and subjective improvements, but there is a large variation. An explanation may be the difference in characteristics[9,16,17] and the durability of the fibers during use, because for clinical relevance not the power delivered by the laser source but the power delivered by the fiber to the tissue is important, the first being the parameter reported in the literature. The laser light transmission of the fibers is one of the major parameters that describe the characteristics of the fiber and that can be used to quantify the durability.

The transmission of eight different side-firing devices was studied here. Three devices (Prolase II, Ultraline, and Urolase) were followed during and after clinical use (durability). The study shows a large difference in laser light transmission, not only between the new devices, but also after use between different samples of one device. In general, the transmission decreased with increasing total transmitted energy. However, the correlation was poor. This suggests that transmission should be considered for a proper evaluation study of a device. The inclusion of a transmission measurement during a clinical procedure, as the change in transmission is unpredictable, would be the preferred situation.

Contamination of the reflecting (gold mirror) or transmitting (glass capillary) parts of the fiber tip will lead to absorption of laser light. As a result the temperature at the contaminated place will rise easily over the boiling temperature of water, thus creating vapor bubbles. Of course this happens both in clinical application and inside the power meter. The bubbles will (back) scatter the light, thus influencing the transmission. As bubbles are formed as a result of light absorption, it is impossible to determine the independent effect of absorption or scattering on the transmission of laser light. In the case of the Urolase fibers at 10, 20, and 40 W, there was a significant relationship between visual inspection and transmission. It should, however, be remembered that the situation may be different for a particular sample. For the other two fibers, Prolase II and Ultraline, no correlation could be found.

Apart from the visual inspection as described here, one can make use of other (cystoscopic) indicators to assess the aging of a side-firing fiber. The absence of tissue effects (blanching or carbonization), white flashes generated at the tip of the device due to overheating of the tip, or excessive formation of vapor bubbles at the tip surface (not coming from the tissue) indicate that the device may be deteriorating. A proper transmission measurement can be used to confirm these indicators.

Some parts of the power meter influence the amount of light that is detected. The glass window in front of the detector reflects and absorbs a small part of the laser light. The amount of water between fiber and detector or tissue absorbs some of the laser light as well. The total amount of laser light that not reaches the detector is estimated at about 5%. The results presented here are not influenced by these "errors", because the measurements are calculated relative to an end-firing fiber or relative to a new sample of a side-firing device. The mentioned percentile aberrations are constant in all circumstances. Only when calculating the energy that actually irradiates the tissue in the clinical situation should this 5% difference be considered.

The patients treated with the Prolase II, Ultraline, and Urolase fibers who were included in this study were all evaluated, regarding symptom score and voiding parameters.[14,15] The change in these parameters, however, did not correlate with the decay in transmission of these fibers as assessed in this study. Although the number of patients is small, the absence of correlation may be explained by the fact that transmission of the fiber does not decrease linearly during a procedure. In that case, more accuracy can be obtained by measuring at fixed intervals during a procedure.

Although the transmission is an important factor to take into account, at least for the transmission differences considered here, it does not disqualify one of these side-firing fibers for laser prostatectomy. It does, however, strongly indicate that the transmission should be considered when comparing different fibers. By measuring the delivered energy to the tissue more accurately with a setup as the "Aquarius" power meter, one will be able to compare the results of different laser prostatectomy studies and understand the differences better.

Conclusions

The present study shows a difference in laser light transmission between side-firing devices for laser prostatectomy. This transmission may change during clinical application in an unpredictable way. Despite the same device and applying the same power settings, the energy delivered to the tissue during a clinical procedure can vary significantly

Power measurement during a clinical treatment will contribute to a more controlled procedure and to a better comparison of clinical laser prostatectomy studies.

References

1 Littrup PJ, Lee F, Borlaza GS, Sacknoff EJ, Torp-Pedersen S, Gray JM Percutaneous ablation of canine prostate using transrectal ultrasound guidance absolute ethanol and Nd YAG laser Invest Radiol **23** 734, 1988

2 Bloiso G, Warner RS, Cohen MS Treatment of urethral diseases with neodymium YAG laser Urol **32** 106, 1988

3 Johnson DE, Levinson AK, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, Wishnow KI Transurethral laser prostatectomy using a right-angle delivery system, in Watson GM, Steiner RW, Pietrafitta JJ Lasers in Urology, Laparoscopy and General Surgery, Bellingham, SPIE vol **1421** 36, 1991

4 Roth RA, Aretz HT Transurethral ultrasound-guided laser-induced prostatectomy (TULIP procedure) a canine prostate feasibility study J Urol **146** 1128, 1991

5 Johnson DE, Price RE, Cromeens DM Pathologic changes occurring in the prostate following transurethral laser prostatectomy Lasers Surg Med **12** 254, 1992

6 Kabalin JN Laser prostatectomy performed with a right angle firing neodymium YAG laser fiber at 40 watts power setting JUrol **150** 95, 1993

7 Verdaasdonk RM, Borst C, van Gemert MJC Explosive onset of continuous wave laser tissue ablation Phys Med Biol **35** 1129, 1990

8 Van Swol CFP, Verdaasdonk RM, Mooibroek J, Lock MTWT, Boon TA Prediction of the necrotic zone depending on the optical and thermal characteristics of laser prostatectomy modalities J Urol **151** 419A, 1994

9 Van Swol CFP, Verdaasdonk RM, Van Vliet RJ, Molenaar DG, Boon TA Side-firing devices for laser prostatectomy an overview, World J Urol **13** 88, 1995

10 Van Swol CFP, Verdaasdonk RM, Mooibroek J, Boon TA Optimization of laser prostatectomy, Prog Clin Biol Res **386** 511, 1994

11. Cowles III RS, Rawlings CA: The effect of intraprostatic blood flow on laser energy penetration in the canine prostate, Lasers Surg Med **Suppl** 7: 63, 1995
12. Van Swol CFP, Verdaasdonk RM, Hermans F, van Vliet RM, Boon TA: Monitoring of the quality of side-firing fibers using a special design power meter "Aquarius", in Watson GM, Steiner RW, Johnson DE. Laser prostatectomy and lasers in urology, Bellingham, SPIE vol **2395A**: 14, 1995
13. te Slaa E, van Ettergem AF, van 't Hof CA, Debruyne FMJ, de la Rosette JJMCH. Durability of laser fibers, World J Urol **13**: 83, 1995.
14. Boon TA, van Swol CFP, van Venrooij GEPM, Beerlage HP, Verdaasdonk RM. Laser prostatectomy for patients with benign prostatic hyperplasia: a prospective randomized study comparing two different techniques using the Prolase II fiber. World J Urol **13**: 123, 1995
15. De la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ. Experience with the ultraline and urolase laser fibers. is there any difference? World J Urol **13**: 98, 1995
16. Anson K, Buonaccorsi G, Eddowes M, MacRobert A, Mills T, Watson G. Comparative optical analysis of laser side-firing devices: a guide to treatment. Br J Urol **75**: 328, 1995
17. Perlmutter AP, Muschter R. The optimization of laser prostatectomy part I: free beam side fire coagulation Urol **44**: 847, 1994

The influence of the decay of laser fibers during laser prostatectomy on the clinical results.

Submitted

Summary

Objective To assess the influence of the decay of a laser fiber during a laser prostatectomy on the clinical outcome parameters.

Materials and Methods Three types of side-firing laser fibers (34 Urolase, 20 Ultraline and 14 Prolase II) were visually inspected after a laser prostatectomy and transmission measurements were performed using a power meter (Aquarius). These results were correlated with the clinical outcome parameters.

Results Despite differences in the amount of loss in transmission for the fibers used, we could not establish any significant effect on clinical outcome parameters, such as improvement in maximal flow rate or IPSS symptom score. The visual aspect of the Urolase fibers was significantly related to the amount of transmission loss, while no such relation for the other two types of fibers was found. Prostate size and the total amount of energy delivered by the laser source did also not relate with the clinical outcome parameters.

Conclusion To determine the relation between the energy absorbed in the prostate and clinical outcome parameters, a large number of patients must be evaluated and any parameter that can be controlled needs to be monitored. For the latter the power meter as presented here is a useful complimentary tool.

Introduction

Since the canine feasibility studies of Johnson et al.[1] and Roth et al.[2] in 1991 and the first laser prostatectomies with a side-firing device in men published by Costello et al.[3] in 1992, laser prostatectomy has been established as an alternative for the treatment of symptomatic benign prostatic enlargement (BPE). An increasing number of papers document results after laser prostatectomy comparable to those achieved after transurethral electroresection of the prostate (TURP).[4-8] Although laser prostatectomy has several advantages over TURP (e.g. minimal bleeding, no fluid absorption, shorter hospital stay), there are still some disadvantages of laser treatment of the prostate. Amongst others, irritative voiding complaints can occur up to 4-6 weeks post-treatment as well as a prolonged duration of catheterization and a higher incidence of urinary tract infection.[9] Consequently, the development of laser applications and the techniques used are still evolving to improve the clinical outcome and reduce the post-treatment morbidity.

Although the majority of studies[10-14] showed good subjective and objective results, the amount of improvement varies considerably. Because the laser source in all these studies was the same (i.e. an Nd:YAG laser), the differences in clinical outcome may be explained by differences in 1) side-firing devices, 2) laser-technique, 3) power setting and amount of laser energy delivered, 4) prostatic tissue variables (volume, stroma-to-epithelial ratio, blood circulation, colour of the mucosa) and 5) other factors that will influence power density, such as distance of the fiber tip to the prostatic tissue surface, angle at which the laser beam enters the prostate, vapor bubble formation at the fibertip. To develop the optimal treatment dosimetry studies were performed with different fibers and applying different techniques.[15-19] Some of the previous mentioned variables will change during treatment. Changes in blood circulation and colour of the mucosa influence both the amount of laser energy absorbed and the induced temperature rise. The degradation of the quality of a laser fiber during a treatment influences the amount of energy delivered to the prostate and thus affects clinical outcome. To investigate the influence on the clinical outcome caused by a change of laser fiber properties, the present study was conducted.

Material and Methods

Treatment

In a group of 68 patients with complaints due to BPE a laser treatment was performed with the Urolase, Ultraline or Prolase II side-firing fiber. The Urolase fiber was used in a four quadrant technique in a 40 Watts 90 sec. setting. The Ultraline and the Prolase fiber were used in a painting manner in a 60 and 40 Watts setting respectively. After treatment the energy delivered by the laser source was recorded. All treatments were performed with a new fiber.

Assessment of clinical outcome

All patients underwent a screening program including history (IPSS symptom score), physical examination (including DRE), urine culture and urinalysis, laboratory investigations (including PSA) and transrectal ultrasonography. Objective voiding parameters were evaluated by uroflowmetry, post voiding residual and urodynamic investigations with pressure flow study analysis.

Visual inspection

To asses a possible relation between the clinical outcome of laser prostatectomy and the quality of the laser fibers, we examined the used laser fibers visually. Only fibers which were used during an entire laser prostatectomy were inspected, thus fibers which were burned to destruction during a laser treatment and replaced by a new fiber were excluded. The fiber tips were inspected by two independent observers (E te S and J de la R), who scored the fiber tips from 1 to 5 according to the degree of damage (1 = undamaged, 5 = severely damaged). The sum of the scores given by the two observers was considered to be the score for a particular fiber. This method has been extensively described in another paper.[20]

Transmission measurements

To assess the percentage of energy loss transmission measurements were performed with a power meter, developed by the Laser Center in Utrecht, the Netherlands. This specially designed water-cooled power meter, named "Aquarius", measures the transmission of the laser fibers under clinical conditions being under water and at a high power setting (40-60 Watt). All laser fibers were cleaned with a brush and water and inserted in the water-filled power meter. All fibers were positioned at the same distance to the detector. Water flow parallel with the fiber could be incorporated with a flow of 3.0 ml/sec.[21] As a reference, transmission measurements were performed of new fibers.

Statistical analysis

To investigate if there was a statistical dependency between transmission loss and the clinical outcome parameters, the Kendall test for rank correlation was used. According to the clinical outcome, patients were considered a responder (excellent and good), an intermediate responder (fair) and a non responder as

Table 1. *Response criteria for the IPSS symptom score and the maximum flow rate (MFR) in ml/s according to the 2nd International Consultation on BPH.*[22]

		Response criteria			
		Responder		Intermediate	Non-responder
Parameter		Excellent	Good	Fair	None
IPSS	post/pre ratio	-	≤ 60%	≤ 80%	> 80%
			and	and	or
	post score	≤ 7	≤ 13	≤ 20	> 20
MFR	post/pre ratio	-	≥ 130%	≥ 130%	< 130%
			and	and	or
	post score	≥ 18	≥ 12	≥ 6	< 6

recommended by the WHO (Table 1).[22] The Kruskal-Wallis test was used to investigate if the amount of transmission loss was the same for each response category.

Results

Clinical data and results from fiber investigations were available from a total of 68 laser procedures (34 Urolase, 20 Ultraline and 14 Prolase II). In Table 2 the clinical outcome data are shown for the three fibers. The results for the Prolase II fiber were somewhat less than those for the Urolase and the Ultraline.

Table 2. *Mean IPSS and maximal flow rates (MFR) with standard deviation (Sd) for the three types of fibers.*

		Type of fiber					
		Urolase (n=34)		Ultraline (n=20)		Prolase (n=14)	
		mean	Sd	mean	Sd	mean	Sd
MFR	pre	7.7	2.9	7.2	2.6	9.1	4.1
	post (6 months)	17.3	5.7	16.3	6.5	14.4	6.9
	100% x (post-pre)/pre	162	163	160	164	83	128
IPSS	pre	21.5	5.1	20.3	5.4	18.3	6.0
	post (6 months)	6.0	7.4	5.5	4.3	7.3	4.9
	100% x (post-pre)/pre	-73	33	-69	28	-62	21

There was an average increase of 83 % in maximal flow rate and a 62 % decrease in IPSS symptom score for the Prolase II group; this was 162 % and 73 % for the Urolase group and 160 % and 69 % for the Ultraline group. The loss of transmission was at average 33% for the Urolase fibers, 28% for the Ultraline fibers and 48% for the Prolase II fibers (Table 3). Other variables which could have influenced the clinical outcome data are the total energy delivered by the laser and the volume of the prostate. As is shown in Table 3 as well the mean total energy is 43,159 Joules for the Urolase group, 48,255

Table 3. *Mean transmission percentage, total amount of energy delivered (Joules) and prostate volume (ml) for the three types of fibers.*

	Type of fiber					
	Urolase (n=34)		Ultraline (n=20)		Prolase (n=14)	
	mean	Sd	mean	Sd	mean	Sd
% transmission	67	18	72	10	52	19
total energy (Joules)	43,159	15,116	48,255	14,211	35,119	16,534
Prostate vol. (cc.)	48	17	47	17	61	19

Joules for the Ultraline group and 35,119 Joules for the Prolase II group. The mean volume of the prostate for the Urolase group is 48 ml, for the Ultraline group 47 ml and for the Prolase II group 61 ml. Table 4 shows the results of the visual inspection of the fibers. At the time of inspection there were 33 Urolase, 18 Ultraline and 12 Prolase fibers. Altogether, more fibers were severely damaged in the Ultraline and the Prolase II groups. This is probably

Table 4. *Results of visual inspection of the three types of fibers after a laser prostatectomy. Grade 2-4 is not to slightly damaged, grade 5-10 is moderate to severely damaged*

	Type of fiber		
Visual aspect	Urolase (n)	Ultraline (n)	Prolase (n)
not inspected	1	2	2
grade 2-4	21	6	3
grade 5-10	12	12	9

a result of using these fibers in a painting way while accidentally making contact. For all three fibers, with the Kendall correlation test no significant relation between the amount of transmission loss and both the relative changes in maximum flowrate and symptom scores (Table 5) could be found. Using the Kruskal-Wallis test there is no significant difference in the amount

Table 5. *Kendall correlations (r) between loss of transmission and absolute (Δ (post-pre)) and relative (100% x post/pre) changes in maximal flow rate (MFR) and IPSS. (ns = not significant)*

		Type of fiber					
		Urolase		Ultraline		Prolase	
		r	p	r	p	r	p
MFR	Δ (post-pre)	0,016	ns	0,038	ns	0,054	ns
(ml/s)	100% x post/pre	-0,06	ns	0,096	ns	0,182	ns
IPSS	Δ(post-pre)	-0,05	ns	0,092	ns	0,306	ns
	100% x post/pre	-0,11	ns	-0,06	ns	0,122	ns

of transmission loss between the response categories for the maximum flow rate (Table 6a). But for the Urolase group there seemed to be a significant difference in loss of transmission between the response categories for the symptom scores (Table 6b). Concerning the maximum flow rate, the responders percentage is 82 % for the Urolase group, 70 % for the Ultraline group and 43 % for the Prolase II group. For the IPSS symptom score the responders percentages are 88 % , 85 % and 79 % respectively.

The visual aspects of the Urolase fibers were related to the amount of transmission loss. The more visually damaged the fiber tip, the higher the

Table 6. *Relation between the different responder groups for maximal flow rate (a) and IPSS (b) and transmission percentage in the three types of fibers, with the Kruskal-Wallis test. (ns = not significant)*

	% Transmission								
6a	Urolase			Ultraline			Prolase		
	n	mean	Sd	n	mean	Sd	n	mean	Sd
Responder	28	71	15	14	71	10	6	49	11
Intermediate	3	50	28	4	73	14	3	69	27
Non responder	3	51	24	2	75	10	5	47	21
Kruskal-Wallis		ns			ns			ns	

6b	% Transmission								
	Urolase			Ultraline			Prolase		
	n	mean	Sd	n	mean	Sd	n	mean	Sd
Responder	30	71	14	17	71	11	11	51	19
Intermediate	2	42	10	1	67	-	3	57	26
Non responder	2	31	4	2	77	8	0	-	-
Kruskal-Wallis	p =0.0077			ns			ns		

transmission loss. For both other fibers the same, however not significant, trend was observed (Table 7).

We couldn't find any correlation using the Kruskal-Wallis test between the clinical outcome parameters and both the total amount of delivered energy and the prostate volume.

Table 7. *Relation between transmission percentage in the three types of fibers and the visual aspects, using the Kruskal-Wallis test. (ns = not significant)*

	% Transmission								
	Urolase			Ultraline			Prolase		
Visual aspects	n	mean	Sd	n	mean	Sd	n	mean	Sd
grade 2-4	21	75	12	6	75	6	3	68	14
grade 5-10	12	51	14	12	69	12	9	50	21
Kruskal-Wallis	p = 0.0002			ns			ns		

Discussion

Since the first publications of side-firing laser devices in the treatment of symptomatic BPE by Costello[3] and McCullough,[23] several reports were published which showed subjective and objective improvement after laser prostatectomy.[10-14] Laser treatment has potential less complications compared to the "gold standard" TURP. The few randomised studies performed until now showed no significant difference in clinical outcome between laser prostatectomy and transurethral electroresection of the prostate.[4-8] At present more than 10 different fibers are under investigation in clinical trials to perform laser prostatectomy.

The beam characteristics of these different types of fibers have been investigated. These studies showed a wide variety in beam characteristics amongst the devices and thus in power density on the tissue.[24,25] Aside from the physical differences, the fibers are clinically applied using various techniques (contact vs. non contact, fixed position vs. painting) and various laser settings (60 Watts for 60 sec., 40 Watts for 90 sec. or 15 Watts for 180 sec). The dosimetry for some side-firing devices was derived from studies in a potato model and in canine prostates leading to a specific protocol for each type of fiber.[16-19] However, in human studies, there were no significant differences in clinical results comparing various devices and techniques.[13-15,26] Only the clinical outcome of the Prolase II fiber at 40 Watts in the present study was not as good as those of the other two fibers (Table 2). In another study using the Prolase II fiber at 60 W better results were obtained.[14]

Because many parameters are involved and the number of patients in each study is relatively small, it is not surprising that no significant data could be found in each of these studies indicating optimal settings. Despite the large scatter in the clinical data, the average clinical outcome was satisfying and comparable with results after TURP. In order to obtain significant data one has to control and measure all parameters as good as possible starting with the power density at the tissue and the total energy delivered to the tissue. These parameters can be derived from a simple transmission measurement under clinical conditions before and after the treatment as performed in this study.

In the present study we could not find a correlation between the transmission decrease and the clinical outcome parameters for the three investigated fibers. The only significant correlation found was between the transmission loss in the Urolase fibers and the symptomatic responders. Although significant we have to realise that there were only two patients in the non responder group. Overall the fact that all the non responder groups consists of only a few patients will make it difficult to find any significant relation between baseline parameters and clinical outcome. Furthermore, the degradation process of the fibers leading to the loss in transmission is considered to occur linearly during the procedure. We do not know whether this loss of transmission is gradually or whether it is the result of a particular event during the laser procedure. As a result one fiber may have a transmission loss already at the beginning while another one looses transmission just before the end of a laser prostatectomy. The result may be that both have the same transmission loss at the end of the laser procedure, but the total energy delivered to the tissue will be less for the first fiber as compared to the second. Measuring the transmission during the treatment, e.g. when fiber tip changes occur or at fixed intervals (e.g. after every 10,000 J), leads to a more accurate determination of the energy delivered to the tissue and may facilitate to reveal a relation between clinical outcome parameters and the actual energy delivered. It was observed that under clinical conditions degradation of the fibers leads not only to transmission loss but also generated vapor bubbles as the temperature of the degraded fiber tip rises above 100°C.[21] These bubbles cause additional losses and dispersion of the laser beam resulting in a lower power density.

Apart from actual measurements one can also inspect the fiber tip to describe the extent of damage. Concerning this visual aspect, its clear that when a fiber is severely damaged (grade 5) we have to replace it by a new fiber. But what to do when a fibertip looks slightly to moderately damaged or undamaged? The present study showed no significant relation between the visual aspects and the amount of transmission loss for the Ultraline and the Prolase II fiber but there is a relation for the Urolase fiber. Most likely this is the result of the differences in the material the fiber tip is made of, the manner of beam deflection and the laser technique used. We had the same result in an earlier study in which we performed transmission measurements at very low power setting.[20] We concluded that visual aspect alone is not a reason to decide if a fiber should be replaced or not. Only transmission measurements form a good indication as to the efficacy of a fiber. Transmission measurements applied to a larger series of patient treatments may provide sufficient data to determine whether there is a relationship between transmission loss and clinical outcome.

Finally, also the influence of prostate volume and total amount of laser energy used, was not related with the clinical result

In conclusion, although differences in transmission decrease for the used fibers were obvious, no significant effect on the clinical outcome parameters could be found. A considerable number of factors influence the amount of energy that eventually will be absorbed in the prostate. Furthermore the number of non responders are small. Therefore, to determine the relation between the energy absorbed in the prostate and clinical outcome parameters, a large number of patients must be evaluated and any parameter that can be controlled needs to be monitored. For the latter the power meter as presented here is a useful complimentary tool.

References

1 Johnson DE, Levinson AK, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, Wishnow KI Transurethral laser prostatectomy using a right-angle laser-delivery system Lasers Urol Laparoscopy Gen Surg **1421** 36, 1991

2 Roth RA, Aretz HT Transurethral ultrasound-guided laser-induced prostatectomy (TULIP procedure) a canine prostate feasibility study J Urol **146** 1128, 1991

3 Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J Laser Ablation of the Prostate in Patients with Benign Prostatic Hypertrophy Br J Urol **69** 603, 1992

4 Kabalin JN, Gill HS, Bite G, Wolfe V Comparative study of laser versus electrocautery prostatic resection 18-month follow-up with complex urodynamic assessment J Urol **153** 94, 1995

5 Schulze H Tulip transurethral ultrasound-guided laser-induced prostatectomy World J Urol **13** 94, 1995

6 Buckley JF, Ligam V, Peterson P, on behalf of the British ELAP Group Endoscopic Laser ablation of the prostate gland J Urol **151** 229A, 1994

7 Costello AJ, Crowe HW A single institution experience of reflecting laser fiber prostatectomy over four years J Urol **151** 229A, 1994

8 Dixon C A comparison of transurethral prostatectomy with visual laser ablation of the prostate using the Urolase right-angle fiber for the treatment of BPH World J Urol **13** 126, 1995

9 te Slaa E, de Wildt MJAM, Debruyne FMJ, de Graaf R, de la Rosette JJMCH Urinary Tract Infections Following Laser Prostatectomy Is There a Need for Antibiotic Prophylaxis? Br J Urol **77** 228, 1995

10 Kabalin JN, Bite G Three years experience with Neodymium YAG Laser Coagulation Prostatectomy in 225 Patients J Urol **153** 229A, 1995

11 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual Laser Ablation of the Prostate Clinical Experience in 108 Patients J Urol **150** 1612, 1993

12 Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R Outpatient Visual Laser-Assisted Prostatectomy under Local Anesthesia Urol **43** 149, 1994

13 De la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the Ultraline and Urolase laser fibers Is there any difference? World J Urol, **13** 98, 1995

14 Gill HS, Kabalin JN, Leach GE, Bowers G, Barken I Laser ablation of the Prostate with the Prolase II lateral firing fiber a multicenter study J Endourol **Suppl. 7** S127, 1993

15 Shanberg AM, Lee IS, Tansy LA, Sawyer DE, Rodgers LW, Ahlering T Depth of penetration of the Neodymium Yttrium-Aluminium-Garnet Laser in the Human Prostate at various Dosimetry Urol **43** 809, 1994

16 Kabalin JN, Gill HS Dosimetry Studies Utilizing the Urolase Right Angle Firing Neodymium YAG Laser Fiber Lasers Surg Med **14** 145, 1994

17 Orihuela E, Motamedi M, Cammack T, Torres JH, Pow-Sang M, Lahaye M, Cowan DF, Warren MM Comparison of Thermocoagulation Effects of Low Power, Slow Heating versus High Power, Rapid Heating Nd YAG Laser Regimens in a Canine Prostate Model J Urol **153** 196, 1995

18 Perlmutter AP, Muschter R The Optimization of Laser Prostatectomy Part I Free Beam Side Fire Coagulation Urol **44** 847, 1994

19 Muschter R, Perlmutter AP The Optimization of Laser Prostatectomy Part II Other Lasing Techniques Urol **44** 856, 1994

20 te Slaa E, van Ettergem AF, van 't Hof CA, Debruyne FMJ, de la Rosette JJMCH Durability of laser fibers World J Urol 13 83, 1995

21 van Swol CFP, te Slaa E, Verdaasdonk RM, de la Rosette JJMCH, Boon TA Variation in output power of laser prostatectomy fibers a need for power measurements Urol **47** 672, 1996

22 Boccon-Gibon L, Brendler CB, Calais da Silva F, Cockett ATK, Fowler JE, Homma Y, Moriyama N, Okijama E, Richard F Clinical Research Criteria

Proceedings, The 2nd International Consultation on Benign Prostatic Hyperplasia 345, 1993

23 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier HA, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy National Human Cooperative Study results J Urol **150** 1607, 1993

24 van Swol CFP, Verdaasdonk RM, van Vliet RJ, Molenaar DG, Boon TA Side-firing devices for laser prostatectomy World J Urol **13** 88, 1995

25 Anson K, Buonaccorsi G, Eddowes M, MacRobert A, Mills T, Watson G A comparative optical analysis of laser side-firing devices a guide to treatment Br J Urol **75** 328, 1995

26 Boon TA, van Swol CFP, van Venrooij GEPM, Beerlage HP, Verdaasdonk RM Laser prostatectomy for patients with benign prostatic hyperplasia a prospective randomized study comparing two different techniques using the Prolase-II fiber World J Urol **13** 123, 1995

Chapter 3

Clinical results of laser prostatectomy

Based on:

J.J.M.C.H. de la Rosette, E. te Slaa, M.J.A.M. de Wildt, F.M.J. Debruyne.
*Experience with the Ultraline and Urolase fibers: is there any difference? World J Urol, **13**: 98, 1995*

E. te Slaa, J.J. Mooibroek, Th.M. de Reijke, H.F.M. Karthaus, J.W. van Capelle, N. Tjon Pian Gi, J.J.M.C.H. de la Rosette.
*Laser treatment of the prostate using the Urolase fiber: the Dutch experience. J Urol, **156**: 420, 1996*

Experience with the Ultraline and Urolase fibers: is there any difference?

World J Urol, **13**: 98, 1995

Abstract

Laser treatment of benign prostatic hyperplasia has enjoyed a growing popularity among urologists over the last few years. Various applicators and techniques have been reported. Because this may result in a different overall performance, we performed a prospective randomised study comparing the results of treatment using the Ultraline fiber (n=44) with that using the Urolase fiber (n=49). Although different types of fibers and techniques were used, the results of this study were surprisingly similar for both fibers used. The uroflow for the Ultraline group increased from an average of 7.9 ml/s at baseline to 19.3 ml/s at 3 months and 16.9 ml/s at 6 months.. In the patients treated with the Urolase fiber the uroflow improved from an average of 7.8 ml/s at baseline to 19.5 and 16.3mL/s at 3 and 6 months, respectively. The improvement in symptoms, reflected by changes in the I-PSS symptom scores, for the Ultraline group went from 21.0 at baseline to 7.9 at 3 months, and 6.0 at 6 months. The Urolase patients improved from 21.0 at baseline to 8.2 and 5.6 at 3 and 6 months, respectively. The morbidity mainly consisted of a prolonged need for posttreatment catheterization and irritative symptoms for about 2 to 4 weeks. From this study we concluded that the results achieved by laser treatment of the prostate using the Ultraline and Urolase fiber are both equivocal and excellent; however, the morbidity of these treatments remains considerable.

Introduction

Over the last few decades, transurethral resection of the prostate (TURP) has been the primary choice of treatment to relieve bladder outlet obstruction and symptoms of prostatism. TURP is reported to be a safe and effective procedure. The mortality has been reduced to 0.2% but morbidity remains considerable and constant at 18%.[1] The treatment of BPH is currently undergoing significant reevaluation. The increasing age of the general population and the greater attention paid by older men to the symptoms of prostatism mean that the demand for treatment is almost limitless.

Because of the minor but significant morbidity and the changes in social habits and for economic reasons, a number of alternatives to TURP have emerged in recent years.[2-5] One alternative to TURP that has recently demonstrated significant results is the use of a laser to achieve desobstruction.[6-8] One of the first reports on laser treatment of BPH was published by Costello et al.[9] in 1992. Since then, various authors have reported their clinical experience in using different types of applicators.[7,8,10,11] These applicators, however, differ in their physical properties, overall performance, and tissue effects.

The question as to the type of applicator that should be used is fundamental. The initial experience with laser treatment of benign prostatic hyperplasia (BPH) involved the transurethral ultrasound-guided laser-induced prostatectomy (TULIP) device and the Urolase fiber.[12] The simplicity of the endoscopy-assisted technique made it more attractive than the ultrasound-guided TULIP device. Moreover, the latter procedure caused more morbidity. Following this experience, we proceeded with the side-firing fiber technique. These fibers possess vaporising and coagulation properties. In favour of the vaporising technique is the observation that tissue is vaporised and a lumen is created instantly. On the other hand, a coagulative technique may result in more extensive tissue destruction and, thus, should lead to better results. To date, long-term data have not been available to demonstrate this correlation with clinical results in humans. Therefore, we conducted a study involving a fiber that is primarily used to achieve coagulation (Urolase) and a fiber that can achieve both vaporisation and coagulation (Ultraline).

Patients and methods

From April 1993 until July 1994, 94 men aged 50 to 85 years (average age, 65 years) with symptoms of BPH were randomised to receive treatment with the Ultraline fiber (Heraeus) or the Urolase fiber (Bard). The major inclusion and exclusion criteria for treatment are shown in Table I.

Table 1. *Inclusion and exclusion criteria for laser treatment*

Inclusion criteria	Exclusion criteria
Prostate volume > 30 cm^3	Prostatic carcinoma
Age > 50 years	Bacterial prostatitis
Duration of symptoms > 3 months	Urethral stricture
IPSS >12	Neurogenic bladder dysfunction
Peak uroflow < 15ml/s	Urinary tract infection
	Use of drugs influencing bladder function
	History of TURP or TULIP
	Diabetes mellitus
	Bladder residual urine > 350 ml

Screening included a general history, complete physical examination (including a digital rectal examination), routine blood studies, urine microscopy, and culture. Urine cytology and prostate-specific antigen (PSA) levels were always measured so as to exclude coexisting malignancy. The severity of symptoms was scored using the IPSS questionnaire. Men were also questioned regarding their sexual function (erection and ejaculation). Uroflowmetry (peak flow, Qmax) was performed twice with a minimal voided volume of 100 ml. Residual urine was measured with transabdominal ultrasound. To determine the grade of outlet obstruction we performed an advanced urodynamic investigation including pressure flow analysis. The upper urinary tract was evaluated using a plain abdominal X-ray and renal ultrasound. Transrectal ultrasound of the prostate (TRUS) was performed to measure the volume of the prostate and to determine the prostate configuration. Flexible urethrocystoscopy was used to verify patency of the urethra, and to look for an enlargement of the middle lobe and for signs of malignancy. All patients with an abnormal rectal examination, a PSA level more than 10 ng/ml (Hybritech), and/or abnormal TRUS underwent biopsy.

Patients were randomised after informed consent had been obtained. The Urolase fiber delivery system consists of a 4 m. long Teflon coated fiber with a gold-plated dish at the tip, which allows the laser beam to be reflected at a 90^{o} angle. Sterile water is used as an irrigant through a standard 23 F cystoscope with a 30^{o} angle lens. The Urolase fiber is passed through the working port of the cystoscope. The distribution of the laser energy is customised to the appearance of each prostate. In general, 40 Watts of energy is applied for 90 s to each lateral lobe at the 2, 5, 7, and 10 o'clock positions. In the case of an enlarged middle lobe or a prostatic urethra exceeding 2.5 cm in length, further applications are provided to ensure complete blanching of the lateral lobes. The Ultraline fiber system also consists of a Teflon coated fiber and the beam is deflected using a refractive mechanism. The distribution of the laser energy is applied by a dragging or so-called "painting" technique with the fiber in contact or non-contact mode. A total of 60 Watts of energy is delivered to the prostate lobes during a certain period. To provide relief of symptoms, this technique relies not on tissue sloughing but rather on the immediate creation of an open channel.

Patients were seen 1, 6, 12, 26, and 52 weeks after treatment. When the postvoid residual urine volume was below 100 ml and the micturition was restored satisfactory, the indwelling catheter was removed.

Statistical analysis within each group was done with the Wilcoxon's signed rank test (alpha=0.005), whereas Student's *t*-test (alpha=0.05) was used for comparison between the groups.

Results

The average age of the Ultraline group was 65.0 (range, 50-85) years, and that for the Urolase group was 64.6 (range, 52-79) years. The average prostate volume as measured with TRUS was 45.7 cm^3 for the Ultraline group and 49.7 cm^3 for the Urolase group. There was no statistical difference between the two groups for any given parameter at baseline (Table 2).

In all, 89 patients were available at 12 weeks for assessment and 60 were evaluable at 26 weeks. No patient was lost to follow-up, one patient was treated by TURP, and one patient needed a bladder-neck incision because of a bladder-

Table 2. *Baseline characteristics of the patients evaluated in the present study*

	Urolase (n = 49) mean (Sd)		**Ultraline** (n = 44) mean (Sd)	
Age (years)	64 6	(7 2)	65 0	(6 7)
IPSS	21 0	(5 1)	21 0	(5 9)
Prostatic volume (cm^3)	49 7	(17 2)	45 7	(14 9)
Qmax (ml/s)	7 8	(3 0)	7 9	(2 9)
Voided volume (ml)	200	(95)	196	(89)
Residual volume (ml)	86	(76)	86	(79)
PSA (ng/ml)	5 3	(4 4)	4 9	(3 9)

Table 3. *Main follow-up indices after Urolase and Ultraline treatment*

	Weeks post-treatment			
	0	12	26	52
Ultraline (n)	44	42	32	7
Qmax (ml/s)	7 9	19 3	16 9	19 7
IPSS	21 0	7 9	6 0	6 6
PVR (ml)	86	25	11	32
Urolase (n)	49	47	28	3
Qmax (ml/s)	7 8	19 5	16 3	12 7
IPSS	21 0	8 2	5 6	1 7
PVR (ml)	86	25	12	50

neck sclerosis.

Table 3 shows the subjective and objective changes noted after treatment. For the Ultraline group a significant reduction in IPSS symptom score was shown from an average of 21.0 to 7.9 after 12 weeks, to 6.0 after 26 weeks, and 6.6 after 52 weeks. In the Urolase group the reduction in symptoms was similar to the Ultraline group, with changes from 21.0 at the onset to 8.2 after 12 weeks; to 5.6 after 26 weeks, and to 1.7 after 52 weeks (Fig 1).

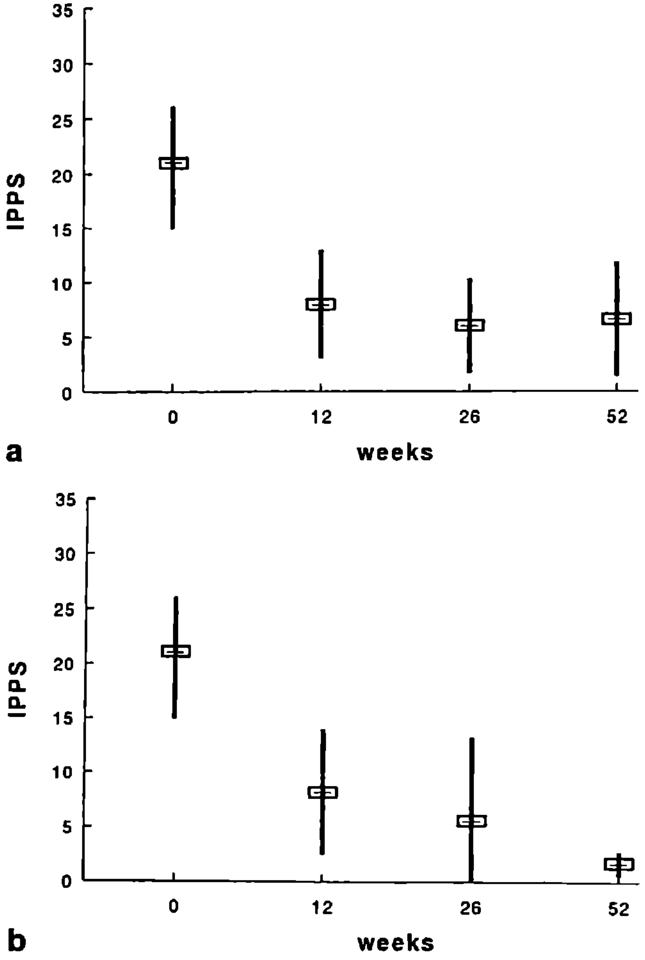


Fig. 1 *Improvement in symptom scores (IPSS) noted for the* ***a*** *Urolase and* ***b*** *Ultraline groups*

Statistical evaluation revealed a statistically significant reduction in symptom score parameters for all values. In the Ultraline group the average improvement was 11.9 mL/s after 3 months and 9.6 mL/s after 6 months. In the Urolase group the average improvement in uroflow was 11.7 mL/s at 3 months and 8.6 mL/s at 6 months (Fig 2). A comparison between the Urolase and Ultraline groups after 12 and 26 weeks of follow up showed no statistically significant difference with regard to symptom score ($P< 0.0001$) or peak flow ($P< 0.0001$).
The same result was found for the postvoid residual urinary volume (Fig 3).

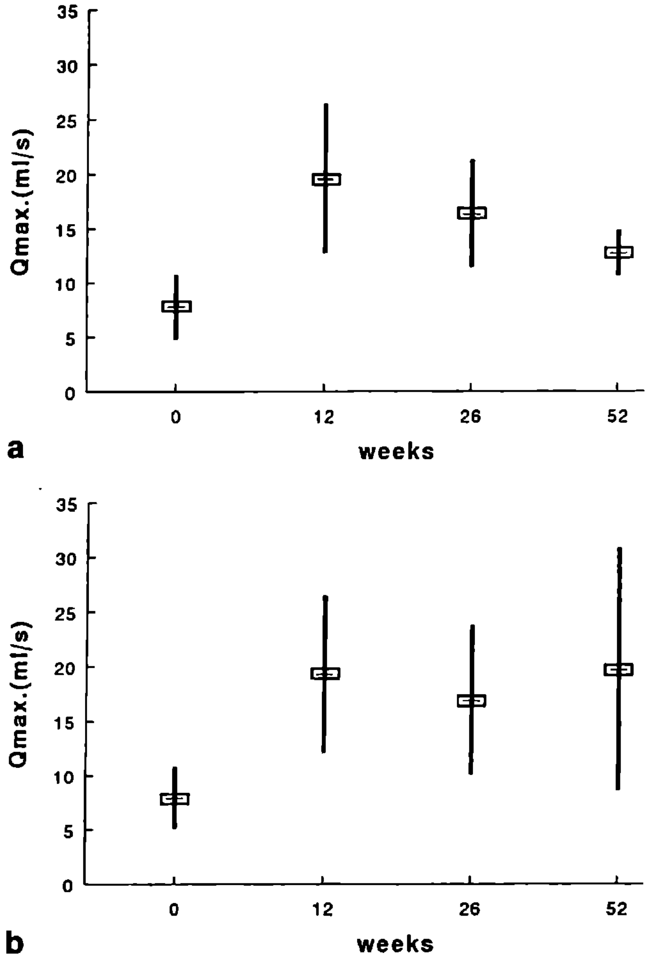


Fig. 2 *Improvement in maximal uroflow (Qmax) noted for the* ***a*** *Urolase and* ***b*** *Ultraline groups.*

The TRUS images obtained after treatment showed cavities at 26 weeks in both the Ultraline and the Urolase groups (Fig 4). No relation was found between the prostate volume and the subjective and objective results obtained. As shown in Table 2, PSA serum concentrations were normal before treatment. When they were measured at 1 day after treatment, there was an elevation in the average PSA value from 5.1 (range, <1.0-17) ng/mL to a mean value of 91 (range, 3.2-290) ng/mL After 3 months, the PSA level returned to normal (Fig 5).

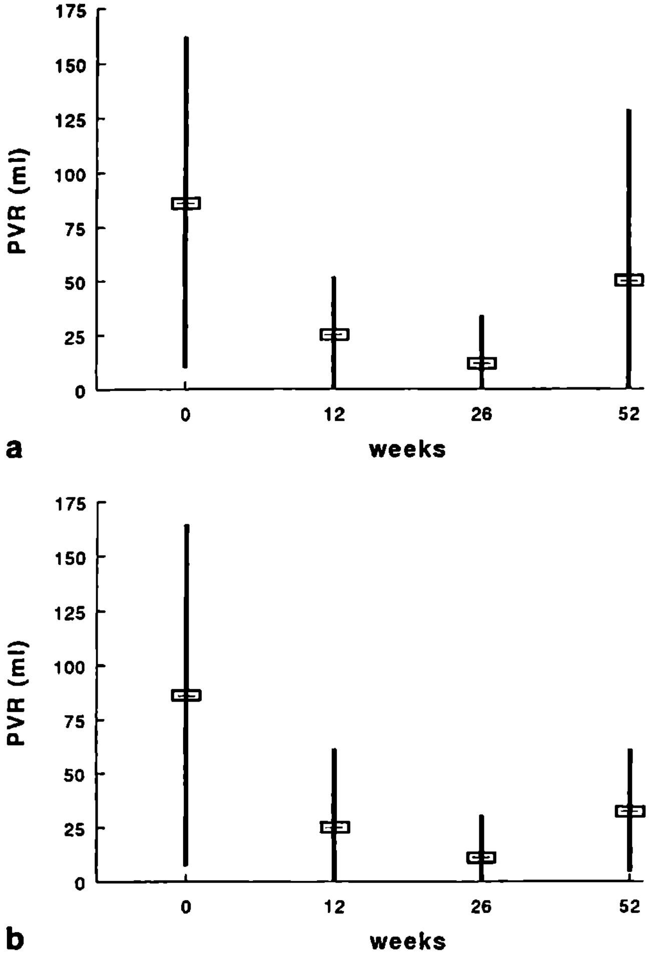


Fig. 3 *Improvement in postvoid residual urinary volume (PVR) noted for the* ***a*** *Urolase and* ***b*** *Ultraline groups.*

No complications occurred during the operation. The predominant complications encountered in both groups posttherapy were prolonged catheterization, urinary tract infections, and (irritative) miction complaints. No incontinence occurred. Patients in the Ultraline group needed an indwelling catheter for an average of 18.9 days, and those in the Urolase group did so for 16.9 days (Fig 6). A retrograde ejaculation was mentioned by 50% of the sexually active patients, whereas 14% of the patients complained of diminished or absent erectile functions.

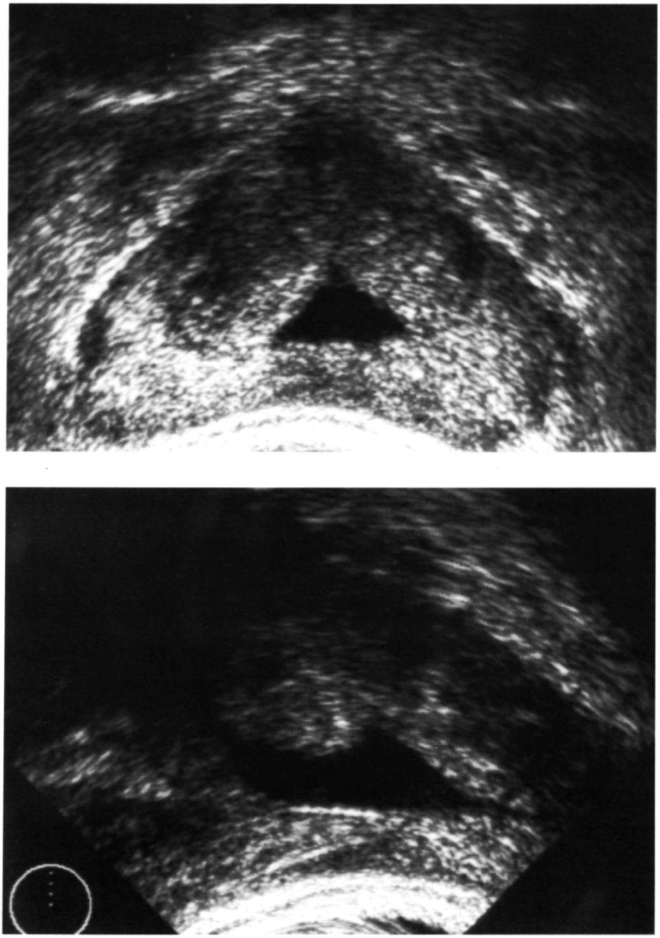


Fig. 4 *TRUS image obtained after laser treatment in the* ***a*** *sagittal and* ***b*** *transverse planes. A nice cavity can be appreciated*

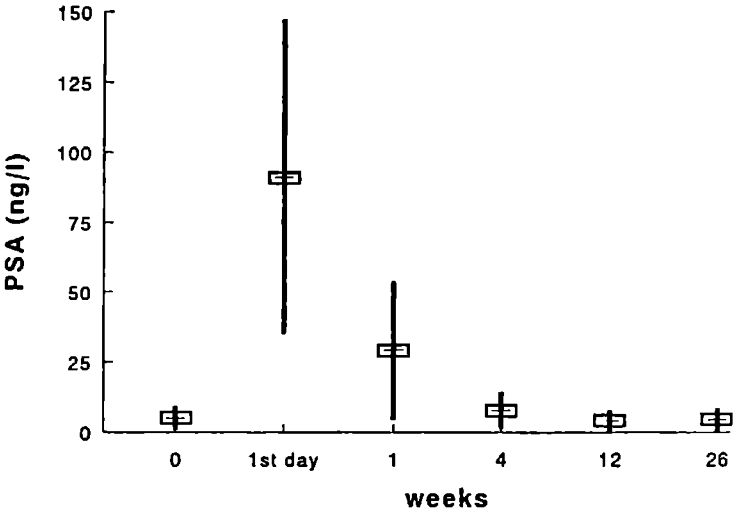


Fig. 5 *Changes observed in PSA levels after Urolase and Ultraline treatment*

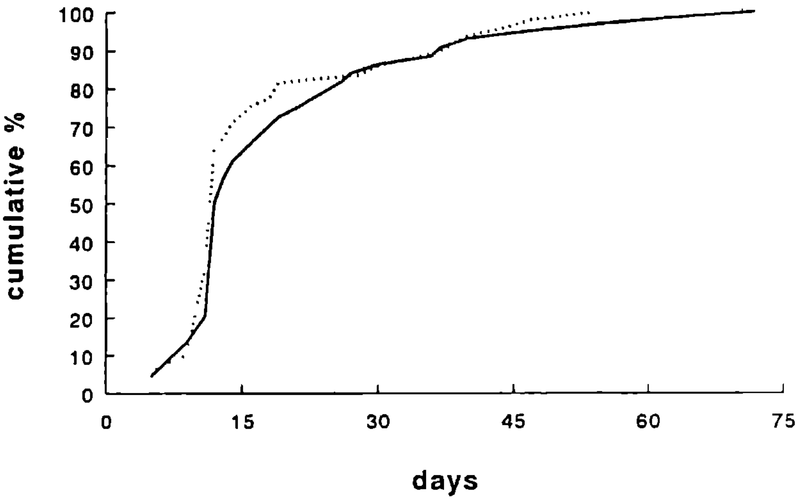


Fig. 6 *Need for suprapubic catheterization in patients treated with the Ultraline (-) and Urolase (....) fibers*

Discussion

Laser light is a unique form of energy with characteristic and variable tissue effects. The Nd:YAG laser produces a tissue effect by converting light energy into thermal energy. Prostatic tissue heated between 60°C and 100°C will undergo protein denaturation and coagulation necrosis. Coagulation results in delayed sloughing of the prostate for a variable period, usually for several weeks after the procedure. At temperatures above 100°C, tissue converts into vapors of water and hydrocarbons, thus creating immediate cavitation. In general, laser energy applied to the prostate is aimed at desobstruction, resulting in improvement in objective and subjective parameters.

The ultimate acceptance of this laser technology relies not only on an improvement in treatment-related morbidity but also on results comparable with those of TURP. The most common method of performing laser ablation of BPH has been the noncontact coagulation technique, which uses low power in the noncontact mode to achieve maximal coagulation and minimal evaporation of tissue. Overall laser treatment using the Urolase fiber results in an average improvement in uroflow of 50%-100% and in a significant decrease in symptoms.[7,9,12-14]

As a result of this early experience, laser prostatectomy has become popular with many urologists because it is associated with morbidity lower than that resulting from TURP. Moreover, the public has become more aware of other treatment options for BPH, and many men are hesitant to consider the traditional option of TURP. Men are particularly concerned regarding the risks of bleeding, impotence, and a prolonged postoperative recovery period. Laser treatment meets most of these requirements.

Thus far, the results obtained after laser treatment have been excellent and approximated those achieved after TURP. The present study shows an increase in uroflow from 7.8 ml/s to 19.5 ml/s at 3 months for the Urolase group and an increase from 7.9 ml/s to 19.3 ml/s at 3 months for the Ultraline group. The subjective improvement, measured with the IPSS questionnaire also showed remarkable results. In Fig. 7 the relation between symptom scores and maximal uroflow at baseline and at 3 and 6 months of follow up is presented.

From this figure it seems obvious that an improvement in uroflow is reflected in a simultaneous improvement in symptoms. However, a significant difference between laser prostatectomy and standard TURP is the lack of immediate effect

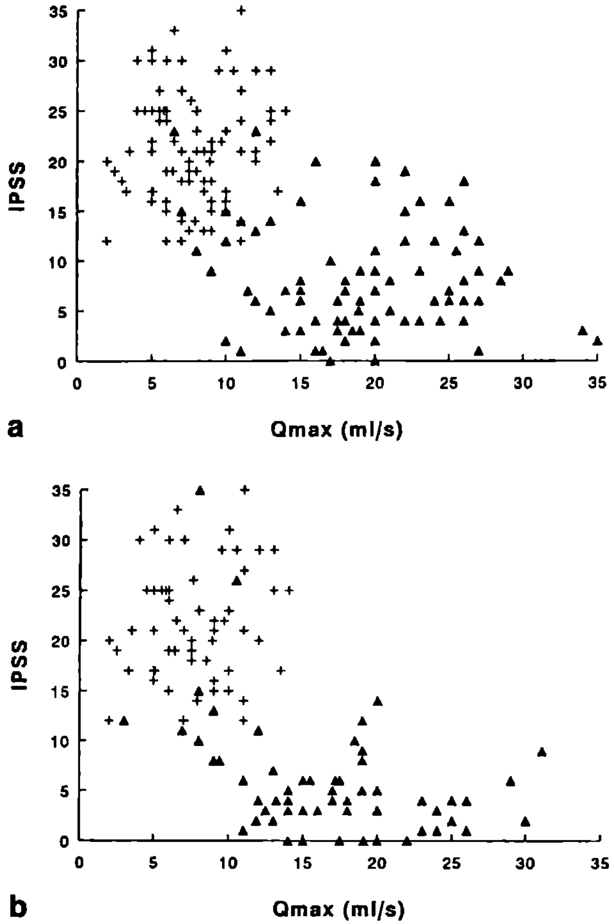


Fig. 7 *Relation between symptom scores (IPSS) and maximal uroflow (Qmax) at **a** 3 and **b** 6 months follow-up (▲). Pre-treatment (+)*

for the former. A standard transurethral prostatectomy removes tissue at the time of the procedure and patients often experience a significant improvement in urinary stream as soon as the indwelling catheter is removed. Although the objective and subjective results achieved by laser therapy using the Urolase or Ultraline fiber in the present study were good, considerable morbidity was noted.

There appeared to be a prolonged need for catheterization in both groups. The

need for prolonged catheterization can be explained by the laser light effect itself. When a Nd:YAG laser beam is incident on prostatic tissue at power densities sufficient to coagulate the prostate, the gland shrinks to a minor extent due to the coagulation effect on protein and to the desiccation of the tissue. The prostate becomes rigid. This is followed by a period of cellular infiltration and swelling of the tissue. The patients will almost universally have a period of retention lasting for an average of 5-20 days. Norris et al.[7] decided to leave the catheter indwelling for 5-7 days postoperatively, and only 17% of the patients required reinsertion of the catheter because of retention. In the present study we inserted a suprapubic catheter prior to treatment. Patients treated with the Ultraline fiber needed catheterization for an average of 18.9 days, whereas those treated with the Urolase fiber had their catheter removed at average on day 16.9. This may also explain the discomfort caused, expressed as irritative symptoms.
Therefore, it was suggested that one should move away from purely coagulative techniques, which do not debulk the prostate to any measurable extent, toward a more vaporising-oriented approach. This treatment modality causes tissue to convert into vapors of water and hydrocarbons, thus creating immediate cavitation. Although we expected to create immediate cavitation using the Ultraline fiber, this did not occur. The results achieved with the Ultraline fiber are comparable with those found after laser treatment with the Urolase fiber. Evaporation of tissue is favored by high-power density, and to obtain maximal power density it is important to keep the fiber close to (i.e., in contact with) the tissue. That we did not use the Ultraline fiber in constant contact with the tissue may explain why the extent of evaporation was less than expected. The main reason for not working in constant contact was that we assumed a more rapid decay of the fibers as a result of contact lasing. Therefore, we think that the effect of the Ultraline fiber, at least in our hands, is a result of coagulation and vaporisation.

Narayan et al.[8] presented their results they obtained using the Ultraline fiber at a higher power setting. The main findings of their study were that in the short term transurethral evaporation of the prostate provided symptomatic relief and improvement in uroflow comparable to that of TURP. As pointed out above, we could not confirm this observation in using the Ultraline fiber. From our study we conclude that a significant reduction in symptom scores and improvement in peak uroflow can be reached with this fiber. The present technique did not, as we expected, result in an earlier recovery of adequate spontaneous micturition and diminution of the symptoms. We think that the side firing fiber, which are mainly used in noncontact mode and at relatively low power setting, are currently incapable of creating sufficient cavitation. The results presented by Narayan et al. suggest that besides being applied in contact, this fiber should be used at a higher power setting. The results of contact lasing are also very promising. These lasing devices seem to be capable of destructing prostates immediately.[11]

As over 20 different devices are available at the moment, one would expect that these would differ in terms of response and outcome. The question as to the type of applicator that should be used is fundamental. In favor of a vaporising technique is the fact that tissue is vaporised and a cavity is created instantly. To our surprise, the results achieved with the fibers used in this study were similar. One might think that the general effect of laser light on tissue would be most important, not the device or technique used. However, Anson et al.[15] showed that pure coagulation treatment using the side firing fibers appeared to show a higher success rate for the Urolase fiber as compared with the Myriadlase system. Another argument that fibers really differ in both their abilities and the outcome of treatment is provided by the results achieved with the contact lasing devices.[11]

Besides the outcome of treatment and the morbidity caused, quality of life is another item to be addressed. An increasing number of (young) men with symptomatic BPH requiring treatment, are concerned about their sexual functions. In the present study, retrograde ejaculation was found in 50% of the patients who were sexually active, whereas 14% mentioned diminished or absent erectile functions. Norris et al.[7] reported retrograde ejaculation in 3 of 37 sexually active men. According to Childs et al.[14], absolutely no retrograde ejaculation was found after laser prostatectomy. Shanberg et al.[16] stated that all patients who were sexually active prior to therapy maintained their potency and described no change in their erections. All but one patient maintained normal antegrade ejaculations as well. This discrepancy may have been caused by more extensive treatment near the bladder neck.

Although the results of laser treatment are encouraging, the morbidity is considerably high. This is related to the device and technique used, among other factors. The optimal Nd:YAG power setting, time for energy delivery, and type of applicator used for laser treatment of the prostate have not yet been defined. The objective of laser treatment must be to find the technique that will maintain a clinically significant outcome, while causing minimal posttreatment morbidity.

Conclusion

It is important to recognise that the term laser prostatectomy encompasses a wide variety of instruments and techniques. The question of appropriate technique and dosimetry has remained an enigma for all urologists. Each laser fiber has its own advantages and limitations, and no single formula exists for the ideal laser treatment. The present study showed no difference in outcome.

References

1 Mebust WK, Holtgrewe HL, Cockett ATK, et al Transurethral prostatectomy Immediate and postoperative complications A cooperative study of 13 participating institutions evaluating 3,885 patients J Urol **141** 243, 1989

2 Oesterling JE Stenting the male urinary tract a novel idea with much promise J Urol **150** 1648, 1993

3 Schulman CC, Zlotta AR, Rasor JS, Hourriez L, Noel JC, Edwards SD Transurethral needle ablation (TUNA) Safety, feasability and tolerance of a new office procedure for treatment of benign prostatic hyperplasia Eur Urol **24** 415, 1993

4 Madersbacher S, Kratzik C, Szabo N, Susani M, Vingers L, Marberger M Tissue ablation in benign prostatic hyperplasia with high intensity focused ultrasound Eur Urol **23 (suppl 1)** 39, 1993

5. Devonec M, Berger N, Perrin B. Transurethral microwave heating of the prostate or from hyperthermia to thermotherapy. J Endourol **5**: 129, 1991
6. Kabalin J. Laser prostatectomy performed with a right angle firing Nd-Yag laser fiber at 40 Watts power setting. J Urol **150**: 95, 1993
7. Norris JP, Norris DM, Lee RD, Rubenstein MA. Visual laser ablation of the prostate: clinical experience in 108 patients. J Urol **150**: 1612, 1993
8. Narayan P, Fournier G, Indudhara R, Leidich R, Shinohara K, Ingerman A. Transurethral evaporation of prostate (TUEP) with Nd:YAG laser uring a contact free beam technique: results in 61 patients with benign prostatic hyperplasia . Urology **43**: 813, 1994
9. Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J. Laser ablation of the prostate in patients with benign prostatic hypertrophy. Br J Urol **69**: 603, 1992
10. Takahashi S, Homma Y, Minowada S, Aso Y. Transurethral ultrasound guided laser induced prostatectomy (TULIP) for benign prostatic hyperplasia: Clinical utility at one-year follow up and imaging analysis. Urology **43**: 802, 1994
11. Watson G, Anson K, Janetschek G, Horninger W, Bartsch G. An indepth evaluation of contact laser vaporisation of the prostate. J Urol **151**: 231A, 1994
12. de la Rosette JJMCH, Froeling FMJA, Alivizatos G, Debruyne FMJ. Laser Ablation of the prostate: experience with an ultrasound guided technique and a procedure under direct vision. Eur Urol **25**: 19, 1994
13. Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R. Outpatient visual laser-assisted prostatectomy under local anesthesia. Urology **43**: 149, 1994
14. Childs S, Alabaster AL, Cowles RS, Dixon C, Kabalin JL, Lepor H, Stein E, Zabbo A. Prospective randomized study comparing transurethral resection of the prostate to visual laser ablation of the prostate. J Urol **149**: 467A, 1993
15. Anson KM, Watson G. Lasers in the treatment of benign prostatic hyperplasia. In: Puppo P (ed) Contemporary BPH management. Monduzzi editore, Bologna, pp 91, 1993
16. Shanberg AM, Lee IS, Tansey LA, Sawyer DE. Extensive neodymium-YAG photoirratiation of the prostate in men with obstructive prostatism. Urology **43**: 467, 1994

Laser treatment of the prostate using the Urolase fiber: the Dutch experience.

J Urol, **156**: 420, 1996

Abstract

Purpose Subjective and objective results were assessed after laser prostatectomy with the Urolase fiber at 5 different centers in the Netherlands.

Materials and Methods Patients were evaluated with the international prostatic symptom score (I-PSS) questionnaire, uroflowmetry and post-void residual volume measurements. Urodynamic investigations with pressure-flow analysis were performed at 2 centers.

Results The data for 233 patients were evaluated. Overall significant improvement in mean international prostatic symptom score, maximum flow, post-void residual volume and urodynamic parameters was noted. Differences in outcome among the centers may be due to a variation of technique or different selection criteria. Postoperative morbidity was significant, with irritative voiding complaints for 4 to 6 weeks in up to 50% of all patients and urinary tract infections in 21.1%.

Conclusion Laser prostatectomy results in subjective and objective improvement, which is operator independent. Despite the observation that perioperative (intraoperative and immediate postoperative) morbidity seems less severe compared to transurethral resection of the prostate, there is a shift toward greater postoperative morbidity.

Introduction

Benign prostatic hyperplasia (BPH) has a high prevalence in men older than 50 years, the majority of whom will eventually have voiding complaints and require treatment.[1] Transurethral electroresection of the prostate has proved to be safe and effective, with excellent long-term results. The mortality rate has been decreased from 2,5 % to 0,2 % but morbidity has remained unchanged at 18 % within the first 90 days after transurethral resection of the prostate[2] and probably is even greater after one year. This morbidity rate is a main reason to seek less invasive treatment modalities, causing minimal morbidity while maintaining the same results as after transurethral resection of the prostate. Despite the challenge of numerous alternative operative and nonoperative therapies,[3-7] transurethral resection of the prostate and open prostatectomy remain the gold standards in the treatment of BPH, mainly because the clinical outcome of alternative treatments is significantly less successful. A promising, recently introduced alternative treatment of BPH seems to be laser energy.

In 1985 Shanberg et al used laser energy in the treatment of BPH.[8] With an end firing, bare fiber used in contact with tissue, causing vaporisation, the main purpose was to make prostatic incisions. The incidence of postoperative bleeding was significant and, furthermore, it was difficult to aim the laser beam at the prostatic lobes. Development of a side firing device solved this problem, and after canine feasibility studies Costello et al performed laser prostatectomies in men with a free beam side firing system under cystoscopic guidance.[9] Mc Cullough et al performed transurethral ultrasound guided laser ablation of the prostate (TULIP).[10] Also, the understanding and acceptance of coagulation as a deeper tissue penetrating effect compared to vaporisation allowed for development of an efficient and effective neodymium:YAG laser procedure. Since then, several different free beam, side firing laser fibers for contact or noncontact use have been developed. Besides side firing fiber techniques, other laser applications for interstitial or contact vaporisation were developed and are currently under clinical investigation.

A widely used and investigated laser fiber is the side firing, noncontact Urolase fiber. Most studies using this device to treat BPH showed good subjective and objective results.[11-14] However, the extent of improvement differed in many studies. We investigated the clinical outcome of laser prostatectomy at different centers in the Netherlands. Is laser prostatectomy operator dependent or can variation in clinical outcome be explained by differences in the treatment protocol?

The only way to demonstrate effectiveness of treatment for BPH is to perform urodynamic investigations before and after procedure. There are few studies of urodynamic investigations used to demonstrate effectiveness of laser prostatectomy.[15-18] We performed urodynamic investigations before and 6 months after treatment of BPH with the Urolase side firing laser at 2 university centers.

Material and Methods

Each participating center included at least 10 patients who underwent laser prostatectomy with the Urolase fiber. Guidelines for selecting patients for laser prostatectomy were age greater than 50 years, duration of symptoms greater than 3 months, international prostatic symptom score (I-PSS) greater than 12, maximum flow less than 15 ml. per second and voided volume greater than 100ml. Despite these criteria, 2 centers treated all patients who normally would undergo a transurethral resection of the prostate. Therefore, from these two centers 3 patients with a maximum flow of more than 15 ml. per second and 7 patients with an I-PSS of less than 12 underwent a laser prostatectomy. Patients in urinary retention, or those with urethral stricture, previous prostatic surgery, diabetes mellitus or neurogenic bladder dysfunction were excluded from the study. All patients were evaluated with I-PSS and sexual function questionnaires, maximum flow and post-void residual volume preoperatively, and at 3, 6 and 12 months postoperatively. Physical examination (including digital rectal examination), transrectal ultrasound with measurement of prostate volume, laboratory investigations (including prostate specific antigen) and urine cultures were performed preoperatively. Urine was also cultured 2 and 4 weeks after removal of the catheter or in cases suspicious of urinary tract infection. Urine was considered infected when culture yielded more than 10^5 per ml. of a pure organism. All patients with an abnormal digital rectal examination and/or elevated prostate specific antigen underwent transrectal ultrasound guided biopsies of the prostate. Patients with a histologically proven adenocarcinoma were excluded from the study.

Urodynamic investigations were performed at 2 centers preoperatively and 6 months postoperatively with an 8 French transurethral lumen catheter and an intravesical microtip pressure sensor. Pressure and flow data were recorded digitally with commercially available equipment and urodynamic analysis software. To quantify grade of obstruction, different parameters were used, including detrusor pressure at maximal flow (grading according to the Abrams-Griffith nomogram),[19] intersection of quadratic urethral resistance relation with the pressure axis of pressure flow (urethral resistance relation: URA) and linear passive urethral resistance relation: L.PURR (an approximation of the resistance relation by a straight line through minimal detrusor pressure and detrusor pressure at maximum flow, with grading according to the Schäfer nomogram).[20]

All patients were treated via the 4-quadrant technique at the 2, 5, 7 and 10 o'clock position with a power setting of 40 W. for 90 seconds, which has been described previously.[14] An enlarged middle lobe was treated with 1 or 2 laser applications. Each patient was treated with a new fiber. However, at all centers slight modifications were introduced, and additional prostatic tissue was treated after the 4-quadrant applications. Before laser therapy was begun cystourethroscopy was performed and a Ch.16 suprapubic catheter was introduced. The suprapubic catheter was removed when the patient could void spontaneously with a residual of less than 50 ml.. Patients were discharged from the hospital 1 day postoperatively.

The Kruskal-Wallis test was used for statistical comparison of results among the different centers. The Wilcoxon signed rank test was used for statistical comparison between preoperative and postoperative data.

Results

Data from 233 patients treated in 5 centers were evaluated. The distribution among the different centers, and mean values at baseline for age, prostate volume, maximum flow, post-void residual and I-PSS are shown in Table 1. Except fore age and prostate volume, all the other baseline characteristics were statistically different among the centers according to the Kruskal-Wallis test. When baseline characteristics for the 3 centers that used the inclusion criteria were examined there was a difference between the maximum flow and post-void residual but not for the I-PSS. There was no difference between baseline characteristics for the 2 centers that did not follow the inclusion criteria completely. Data for 200, 180 and 85 patients were available for evaluation at 3, 6 and 12 months. No 12 months data were available from center 3.

Table 1. *Baseline characteristics for centers 1 to 5. (range between brackets)*

	Center				
	1	**2**	**3**	**4**	**5**
No. pts	59	53	31	30	60
Age (yrs)	65.0 (51.2-79.2)	66.7 (55.0-79.3)	66.3 (54.3-78.9)	56.0 (52,5-79.4)	68.7 (54.9-82.8)
Prostate vol. (ml.)	48.7 (30-101)	47.2 (27-100)	45.3 (28-96)	51.5 (17-98)	45.4 (30-96)
IPSS	21.3 (12-32)	20.0 (6-30)	22.6 (18-31)	17.9 (9-31)	21.8 (15-31)
Max. flow (ml/s)	7.9 (2.0-14.0)	8.7 (4.0-23.0)	5.7 (4.0-12.0)	9.6 (3.0-21.0)	6.1 (4.0-12.0)
Post-void residue	86.5 (0-385)	120.9 (0-350)	135.8 (0-250)	99.0 (0-350)	115.7 (0-250)

Uroflowmetry.

Overall, there was an average improvement in mean maximum flow rate plus or minus standard deviation from 7.5 ± 3.2 ml. per second (range 2.0 to 23.0) at baseline to 16.4 ± 5.6 (range 4.0 to 45.0) at 3 months, 16.7 ± 5.2 (range 4.5 to 33.0) at 6 months and 16.3 ± 5.7 (range 5.0 to 33.5) at 12 months (Table 2). All centers achieved significant improvement in maximum

Table 2. *Mean maximum flow at baseline, and at 12, 26 and 52 weeks postoperatively for centers 1 to 5. (* at 26 weeks)*

	Mean max. flow (ml/s) (range)				
Center	**0 Wk.** 233 pts.	**12 Wks.** 200 pts.	**26 Wks.** 180 pts.	**52 Wks.** 85 pts	**p Value***
1	7.9 (2.0-14.0)	18.7 (6.5-45.0)	17.0 (6.9-32.0)	16.8 (5.0-33.5)	< 0.0001
2	8.7 (4.0-23.0)	16.8 (6.0-34.0)	15.8 (5.0-33.0)	13.9 (5.0-26.0)	< 0.0001
3	5.7 (4.0-12.0)	15.0 (8.0-21.0)	16.7 (13.0-22.0)	_	0.0022
4	9.6 (3.0-21.0)	12.6 (4.0-26.0)	14.3 (4.5-30.0)	16.9 (12.0-25.0)	0.031
5	6.1 (4.0-12.0)	15.8 (8.0-22.0)	17.6 (10.0-24.0)	17.1 (12.0-22.0)	< 0.0001
Totals	7.5 (2.0-23.0)	16.4 (4.0-45.0)	16.7 (4.5-33.0)	16.3 (5.0-33.5)	< 0.0001

flow rate at 6 months. However, there was a difference in the extent of improvement per center. Two centers treated 3 patients with a maximum flow of more than 15 ml. per second. Exclusion of data for these 3 patients from statistical analysis will not change the aforementioned results significantly.

Mean individual improvement at 6 months was 160.4% or 10.4 ± 4.5 ml. per second (range -5 to 26.5). Only 11 patients (6%) had no improvement in maximum flow rate at 6 months.

Post-void residual.

Overall, there was an average decrease in post-void residual from 110.4 ± 84.5 ml. (range 0 to 385) at baseline to 31.8 ± 47.5(range 0 to 200) at 3 months, 30.2 ± 50.5 (range 0 to 300) at 6 months and 21.3 ± 39.0 (range 0 to 140) at 12 months. All centers achieved a significant decrease in post-void residual at 6 months (Table 3). Mean individual decrease in post-void residual at 6 months was 61.7% or 83.9 ± 74.3 ml.(range -100 to 345). Only 13 patients (7%) had no decrease in post-void residual at 6 months.

Table 3. *Mean post-void residue at baseline, and at 12, 26 and 52 weeks postoperatively for centers 1 to 5. (* at 26 weeks)*

	Mean Post-Void residue (ml) (range)				
Center	**0 Wk.** 233 pts.	**12 Wks.** 199 pts.	**26 Wks.** 180 pts.	**52 Wks.** 85 pts	**p Value***
1	86.5 (0-385)	29.8 (0-200)	17.4 (0-200)	19.7 (0-140)	< 0.0001
2	120.9 (0-350)	34.0 (0-200)	53.0 (0-200)	17.3 (0-130)	0.0005
3	135.8 (0-250)	38.7 (0-150)	41.7 (0-100)	_	0.0150
4	99.0 (0-350)	13.9 (0-150)	44.0 (0-150)	15.0 (0-60)	0.0180
5	115.7 (0-250)	34.2 (0-170)	22.5 (0-150)	26.8 (0-135)	< 0.0001
Totals	110.4 (0-385)	31.8 (0-200)	30.2 (0-300)	21.3 (0-140)	< 0.0001

I-PSS.

Because not every patient returned the questionnaire during follow-up, at 3, 6 and 12 months only 191, 178 and 79 patients, respectively, were evaluated.

Overall, there was a decrease in symptom score from 21.1 ± 4.8(range 6 to 32) at baseline to 7.1 ± 5.4(range 0 to 23) at 3 months, 4.8 ± 5.0 (range 0 to 35) at 6 months and 3.6 ± 3.7(range 0 to 20) at 12 months. Again all centers achieved a significant decrease in symptom score (Table 4). Mean individual decrease in symptom score at 6 months was 75.5% or 17.1 ± 6.2 (range -9 to 30). Only 5 patients (3%) had no decrease in symptom score at 6 months. Exclusion of data for the 7 patients with an I-PSS of less than 12 for statistical analysis will not change the aforementioned results significantly.

There was no significant difference between the 6 and 12- months results, regarding maximum flow, post-void residual and I-PSS for all centers (except center 3 because no 12 months data were available).

Table 4. *Mean IPSS at baseline, and at 12, 26 and 52 weeks postoperatively for centers 1 to 5. (* at 26 weeks)*

	Mean IPSS (range)				
Center	**0 Wk.** 233 pts.	**12 Wks.** 191 pts.	**26 Wks.** 178 pts.	**52 Wks.** 79 pts	**p Value***
1	21.3 (12-32)	7.9 (0-23)	6.1 (0-35)	4.8 (0-20)	< 0.0001
2	20.0 (6-30)	6.7 (0-23)	5.7 (0-26)	3.0 (0-6)	< 0.0001
3	22.6 (18-31)	4.8 (0-18)	2.9 (0-7)	_	0.0007
4	17.9 (9-31)	7.4 (1-19)	4.7 (0-10)	3.7 (2-7)	0.0117
5	21.8 (15-31)	7.2 (1-22)	3.6 (0-18)	3.1 (0-12)	< 0.0001
Totals	21.1 (6-32)	7.1 (0-23)	4.8 (0-35)	3.6 (0-20)	< 0.0001

Sexual function questionnaire.

Sexual function was assessed using a questionnaire preoperatively and 6 months postoperatively. There were 127 sexually active patients, defined as those with a good erection for sexual intercourse and antegrade ejaculation. Of these patients 47% had retrograde ejaculation postoperatively and 12.6% complained of erectile function that was insufficient for sexual intercourse or absent.

Pressure- flow studies.

Urodynamic investigations were performed in 98 patients preoperatively and 6 months postoperative. There was an improvement in mean detrusor pressure at maximum flow from 77,8 ± 33.5 cm. water (range 28 to 182) to 40,4 ± 20.1 (range 15 to 103). Only 6 patients (6.1%) had no decrease in detrusor pressure at maximum flow. There was a similar improvement in the linear passive urethral resistance relation when using the Schäfer nomogram, as well as in urethral resistance relation (Table 5). Only 3 patients (3.1%) had

Table 5. *Urodynamic parameters before and 26 weeks after laser prostatectomy.*

		Mean (range)		
		0 Wk.	26 Wks.	p Value
Overall	URA	52.2 (13-133)	20.7 (6-70)	< 0.0001
	L-PURR	3.7 (0-6)	1.2 (0-5)	< 0.0001
	Pdet at Qmax	77.8 (28-182)	40.4 (15-103)	< 0.0001
Center 1	URA	51.9 (23-133)	17.7 (6-41)	< 0.0001
	L-PURR	3.6 (1-6)	0.9 (0-4)	< 0.0001
	Pdet at Qmax	76.5 (34-150)	35.7 (15-78)	< 0.0001
Center 5	URA	52.7 (13-101)	25.4 (8-70)	< 0.0001
	L-PURR	3.8 (0-6)	1.7 (0-5)	< 0.0001
	Pdet at Qmax	80.4 (28-182)	47.7 (15-103)	< 0.0001

no decrease in linear passive urethral resistance relation and 6 (6.1%) had no decrease in urethral resistance relation. The Abrams Griffith nomogram showed a shift from the obstructed to the equivocal and unobstructed areas (Fig. 1).

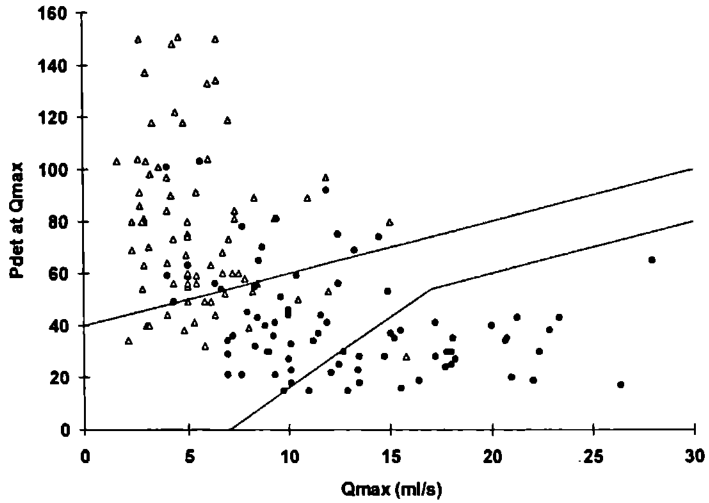


Fig. 1 *Changes in detrusor pressure (Pdet) at maximum flow (Qmax) before and 6 months after laser prostatectomy using Abrams-Griffiths nomogram for centers 1 and 5.* ● *baseline.* Δ *26 weeks.*

Morbidity:

No complications were encountered during laser prostatectomy. Four patients (1,7 %) had urinary retention after removal of the suprapubic catheter and 3 patients (1,3 %) had clot retention. One of the 3 patients required cystourethroscopy with general anaesthesia. No bleeding was noted from the prostatic urethra but bleeding occurred at the entry of the suprapubic catheter, which was controlled with electrocoagulation. No patient with clot retention required blood transfusion. During the first 4 to 6 weeks approximately 50 % of the patients complained of irritative voiding symptoms, which consisted mainly of stranguria, urgency and frequency. Urinary tract infection was diagnosed in 21,1 % of the patients.

Reoperation:

Because of minimal or no improvement after laser treatment transurethral resection of the prostate was performed in 11 patients (4.7%), a second laser treatment in 4 (1.7%) and bladder neck incision in 3 (1.3%). Visual internal urethrotomy was necessary in 1 patient (0.4%) because of urethral stricture. Patients who required transurethral resection of the prostate or a second laser treatment had residual prostatic tissue at cystourethroscopy.

Discussion

Since the first publications of side firing laser fibers for treatment of symptomatic BPH by Costello[9] and McCullough et al[10], reports on laser prostatectomy have increased.[11-14] Although all these studies revealed significant subjective and objective results, there seemed to be a difference in extent of improvement. Similar differences among centers were documented in our study. However, because of different baseline characteristics the results of the individual centers are difficult to compare. All participating centers achieved a significant improvement in I-PSS and maximum flow but there was a difference in extent of improvement among the centers. A reason for this observation may be an alteration in the way laser energy was applied despite the fact that most patients were treated according to the same protocol. Kabalin and Gill described a significant decrease in amount of coagulation necrosis when the laser application was interrupted for approximately 30 seconds.[21] In addition, the distance of the fibertip to the prostatic surface is difficult to standardise and may vary, resulting in different power densities and amounts of coagulation necrosis achieved. Another explanation for differences in results may be variation in the interpretation of the uroflowmetry curves. However, in our study all flow curves were reviewed by 2 independent investigators.

To compare the laser procedure to the gold standard transurethral resection of the prostate, a few randomised studies were performed that showed no statistically significant differences in objective and subjective results between the 2 procedures.[22-25] With regard to morbidity, there appeared to be a shift from perioperative and immediate postoperative morbidity, such as the transurethral resection syndrome, bleeding and the need for blood transfusion (which in the literature is greater for transurethral resection of the prostate), to postoperative morbidity, such as transient voiding complaints, prolonged catheterization and urinary tract infections (which were greater for laser prostatectomy). Naturally, we must note that complications after transurethral resection of the prostate probably are more severe than those after laser prostatectomy. Approximately 50 % of our patients had irritative voiding symptoms lasting 4 to 6 weeks after laser prostatectomy and 21.1% had urinary tract infection. Irritative voiding complaints can be explained partly by the long catheterization period (17 days in our study). On the other hand, several patients with a short catheterization period had irritative voiding complaints for approximately 4 weeks. A previous study showed the same results, but did not demonstrate a relationship between irritative complaints and incidence of urinary tract infection.[26] However, that study showed a relationship between prolonged catheterization and incidence of urinary tract infection, which might also explain the significant incidence of urinary tract infection in our study. Use of a suprapubic catheter in our study, which was removed only when post-void residual was less than 50 ml., could be the reason for this prolonged catheterization. Also, the reoperation rate after 1 year was great in our study, with a transurethral resection of the prostate in 4,7% of the cases, second laser treatment in 1,7% and bladder neck incision in 1,3%. Visual internal urethrotomy was necessary in 1 patient (0,4%). These findings are in contrast to other studies by Kabalin,[11] Norris[12] and Leach[13] et al, who reported only a few patients undergoing a second laser treatment, and only Norris[12] reported 3 patients undergoing a transurethral resection of the prostate after initial laser therapy. This fact may be explained by a shorter follow up in these studies or a difference in selection criteria. It generally is known that European surgeons usually treat patients with more advanced disease, resulting in treatment of larger prostates, and these patients may be at increased risk for reoperation following laser prostatectomy.

However, when analysing the baseline characteristics of patients in whom laser prostatectomy failed and who subsequently required a second laser treatment or transurethral resection of the prostate, we found no significant difference compared to the other patients. Factors, such as differences in prostate tissue texture[27] or those that influence the power density during the laser treatment will explain the differences in clinical outcome.

Previous reports concerning results of laser prostatectomy described only a slight percentage of patients with retrograde ejaculation. In contrast, retrograde ejaculation occurred in 47% of our patients who had normal ejaculation before laser treatment, probably because in our study we were more accustomed to work with lasers and, therefore, applied more energy to the prostate, bladderneck or middle lobe than when one first began laser prostatectomy. Furthermore, 12,6% of our patients who reported no erectile dysfunction before laser prostatectomy had absent or diminished erectile function after treatment. Sexual questionnaires were used to obtain this information, and no objective evaluation was performed. Therefore, it is most likely that some of these patients already had some degree of erectile dysfunction before laser treatment.

Pressure-flow study analysis is the only method to demonstrate objectively relief of bladder outlet obstruction. Since Abrams and Griffith first reported urodynamic changes after surgical intervention for BPH,[19] there have been few studies on this subject. To date only a limited number of studies have been presented using pressure-flow parameters for evaluation of treatment outcome after laser therapy. Bosch et al showed a decrease in detrusor pressure at maximum flow and urethral resistance relation after laser prostatectomy with the TULIP device.[18] de Wildt[17] and te Slaa[16] et al also reported significant improvement in urodynamic parameters after laser prostatectomy with the TULIP device and 2 different side firing lasers (Urolase and Ultraline laser fibers). A randomised study by Kabalin et al showed equal improvement in opening pressure and maximal detrusor pressure in both treatment arms.[15] In our study pressure-flow analysis was performed at centers 1 and 5, and showed overall improvement in urodynamic parameters similar to that in the literature.[15-18] Because pressure-flow analysis results were not inclusion criteria, some patients had no urodynamic obstruction preoperatively. There was no statistically significant difference between the 2 centers. Therefore, we believe that laser prostatectomy is the only documented alternative treatment modality today that can achieve urodynamic results comparable to those of transurethral resection of the prostate in a large series of patients.

Conclusion

Laser prostatectomy results in significant subjective and objective improvement, which is operator independent. However, minor differences may be noted, possibly due to variation of technique or different selection criteria. Despite the observation that perioperative morbidity seems less compared to transurethral resection of the prostate, there is a shift toward greater postoperative morbidity. Pressure-flow analysis shows that laser prostatectomy can relieve bladder outlet obstruction. Future studies should be focused on optimising dosimetry and improving laser technologies, resulting in minimal morbidity, and probably selecting a subgroup of patients who will benefit the most from this treatment modality.

The urodynamic analysis program was developed at the UIC/BME Research Centre, Department of Urology, Nijmegen, The Netherlands.

References

1. Barry MJ. Epidemiology and natural history of benign prostatic hyperplasia. Urol. Clin N Amer **17**: 495, 1990
2. Mebust WK, Holtgrewe HL, Cockett ATK, Peters PC. Writing Commitee (1989). Transurethral prostatectomy: immediate and postoperative complications. A cooperative study of 13 participating institutions evaluating 3,885 patients. J Urol **141**: 243, 1989

3 Lepor H Long term efficacy and safety of terazosin in patients with benign prostatic hyperplasia Urology **45** 406, 1994

4 Stoner E Three year safety and efficacy data on the use of finasteride in the treatment of benign prostatic hyperplasia Urology **43** 284, 1994

5 de la Rosette JJMCH, Tubaro A, Hofner K, Carter S St C Transurethral microwave thermotherapy past, present and future World J Urol **12** 352, 1994

6 Lepor H, Sypherd D, Machi G, Derus J Randomized double-blind study comparing the effectiveness of balloon dilatation of the prostate and cystoscopy for the treatment of symptomatic benign prostatic hyperplasia J Urol **147** 639, 1992

7 Milroy E, Chapple CR The Urolume stent in the management of benign prostatic hyperplasia J Urol **150** 1630, 1993

8 Shanberg AM, Tansey LA, Baghdassarian R The use of the neodymium YAG laser prostatectomy J Urol **133** 331A, 1985

9 Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J Laser Ablation of the Prostate in Patients with Benign Prostatic Hypertrophy Br J Urol **69** 603, 1992

10 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier A, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy National Human Cooperative Study Results J Urol **150** 1607, 1993

11 Kabalin JN Laser prostatectomy performed with a right angled firing neodynium YAG laser fiber at 40 Watts power setting J Urol **150** 95, 1993

12 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual Laser Ablation of the Prostate Clinical Experience in 108 Patients J Urol **150** 1612, 1993

13 Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R Outpatient Visual Laser-Assisted Prostatectomy under Local Anesthesia Urology **43** 149, 1994

14 de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the Ultraline and Urolase laser fibers Is there any difference? World J Urol **13** 98, 1995

15 Kabalin JN, Gill HS, Bite G, Wolfe V Comparative study of laser versus electrocautery prostatic resection 18-month followup with complex urodynamic assessment J Urol **153** 94, 1995

16 te Slaa E, de Wildt MJAM, Rosier PFWM, Wijkstra H, Debruyne FMJ, de la Rosette JJMCH Urodynamic assessment in the laser treatment of benign prostatic enlargement Br J Urol **76** 604, 1995

17 de Wildt MJAM, te Slaa E, Rosier PFWM, Wijkstra H, Debruyne FMJ, de la Rosette JJMCH Urodynamic results of laser treatment in patients with benign prostatic hyperplasia Can outlet obstruction be relieved? J Urol **154** 174, 1995

18 Bosch JLHR, Groen J, Schröder FH Treatment of Benign Prostatic Hyperplasia by

Transurethral Ultrasound-guided Laser-induced Prostatectomy (TULIP): Effects on Urodynamic parameters and Symptoms. Urology **44**: 507, 1994

19. Abrams PH, Griffith DJ. The assessment of prostatic obstruction from urodynamic measurements and from residual urine. Brit J Urol **51**: 129, 1979
20. Schäfer W. Principles and clinical application of advanced urodynamic analysis of voiding dysfunction. Urol Clin N Amer **17**: 553, 1990
21. Kabalin JN, Gill HS. Dosimetry Studies Utilizing the Urolase Right Angle Firing neodymium:YAG Laser Fiber. Lasers in Surg and Med **14**: 145, 1994
22. Schulze H. Tulip: transurethral ultrasound-guided laser-induced prostatectomy. World J Urol **13**: 94, 1995
23. Buckley JF, Ligam V, Peterson P, on behalf of the British ELAP Group. Endoscopic Laser ablation of the prostate gland. J Urol **150**: 229A, 1995
24. Costello AJ, Crowe HW. A single institution experience of reflecting Laser fibre prostatectomy over four years. J Urol **151**: 229A, 1994
25. Dixon C. A comparison of transurethral prostatectomy with visual laser ablation of the prostate using the Urolase right-angle fiber for the treatment of BPH. World J Urol **13**: 126, 1995
26. te Slaa E, de Wildt MJAM, Debruyne FMJ, de Graaf R, de la Rosette JJMCH. Urinary Tract Infections Following Laser Prostatectomy: Is There a Need for Antibiotic Prophylaxis? Br J Urol **77**: 228, 1996
27. Orihuela E, Motamedi M, Pow-Sang M, LaHaye M, Cowan DF, Warren MM. Histopathological evaluation of laser thermocoagulation in the human prostate: optimization of laser irradiation for benign prostatic hyperplasia. J Urol **153**: 1531, 1995

Chapter 4

Urodynamic investigations

Based on:

M.J.A.M. de Wildt, E. te Slaa, P.F.W.M. Rosier, H. Wijkstra, F.M.J. Debruyne, J.J.M.C.H. de la Rosette.

Urodynamic results of laser treatment in patients with Benign Prostatic Hyperplasia. Can outlet obstruction be relieved?
*J Urol, **154**: 174, 1995*

E. te Slaa, M.J.A.M. de Wildt, P.F.W.M. Rosier, H. Wijkstra, F.M.J. Debruyne, J.J.M.C.H. de la Rosette.

*Urodynamic assessment in the laser treatment of Benign Prostatic Enlargement. Br J Urol, **76**: 604, 1995*

Urodynamic results of laser treatment in patients with Benign Prostatic Hyperplasia.

J Urol, **154**: 174, 1995

Abstract

Purpose: A urodynamic study was done to judge the capability of laser treatment to relieve bladder outlet obstruction

Material and Methods: Advanced urodynamic studies with pressure-flow analysis were performed before and 6 months after laser treatment using 3 different laser devices.

Results: Forty patients showed significant improvement in all obstruction parameters (detrusor pressure at maximum flow rate, urethral resistance relation, theoretical cross-sectional urethral area, minimal detrusor pressure and linear passive urethral resistance relation) together with significant subjective improvement in international prostate symptom score. After treatment 82 to 92% of the patients could no longer be considered to have obstruction. No difference in outcome among the devices used was found.

Conclusions: Laser prostatectomy is indeed capable of relieving bladder outlet obstruction.

Introduction

For more than 7 decades prostates have been enucleated surgically and for almost 6 decades they have been resected endoscopically. Results have been impressive and increasingly better, and the procedures are reasonably safe. In the 1980's many alternatives to prostatectomy have surfaced, from a pharmacological approach to numerous procedural alternatives, for example balloon dilatation, prostatic stents, hyperthermia and thermotherapy. To date, none of these alternatives has reached subjective and objective results comparable to those noted after enucleation or resection of the prostate. Nevertheless, the morbidity of the operations is still greater than that for any of these alternatives.

Recently a new instrumental treatment modality for benign prostatic hyperplasia (BPH) became available that is laser treatment of the prostate. The advantages of laser treatment are the minimal hospital stay, minimal bleeding, no fluid absorption, rapidity of treatment, technical simplicity and chance of preservation of antegrade ejaculation.[1] Although present studies include few patients and the follow-up is short, the results after laser treatment are comparable to those achieved after electroresection.[2-7] To replace transurethral resection of the prostate by laser prostatectomy, the latter procedure should also be able to relieve outlet obstruction. In general patients are evaluated preoperatively and postoperatively by means of symptom scores, uroflowmetry studies, post-void residual volume, and prostate size. These parameters are associated with obstructive voiding but not with the grade of obstruction and, therefore, they cannot be used to determine objectively whether outlet obstruction is relieved.[8-10] To quantify the grade of bladder outlet obstruction, urodynamic investigation with pressure-flow analysis is considered the gold standard.[11] We judged the obstruction relieving capabilities of laser treatment of the prostate.

Patients and Methods

Since November 1992 we treated 125 patients with 3 different laser systems:

the Intra Sonix TULIP device, the Bard Urolase fiber and the Heraeus Ultraline fiber. All patients underwent a screening program consisting of physical examination (including digital rectal examination), biochemistry (including prostate specific antigen [PSA]), and urine culture and sedimentation rate. Transrectal ultrasound of the prostate was performed with planimetric measurement of the prostate volume. Furthermore, renal ultrasound was done to exclude hydronephrosis. All patients underwent a urethrocystoscopy to measure the prostate length, and to assess the size of the middle and lateral lobes. In case of a suspicious digital rectal examination, transrectal ultrasound or an elevated PSA level (greater than 10 ng./ml. or a PSA-density of more than 0.15), prostate biopsies were obtained to exclude malignancy. To evaluate the subjective parameters before and after the operation all patients had to complete an international prostate symptom score questionnaire and the symptom score had to be at least 12. Objective parameters were evaluated by a free urinary flow rate using a Dantec Urodyn 1000 uroflowmeter. The voided volume had to be at least 150 ml.. The post-void residual volume, measured by transabdominal ultrasonography, had to be less than 350 ml. If patients fit these criteria, they were eligible for laser treatment.

Urodynamic investigations were performed with an 8F transurethral lumen catheter with an intravesical micro-tip pressure sensor. Abdominal pressure was recorded intrarectally with an 8F micro-tip sensor catheter. Before cystometry the bladder was emptied through the lumen of the transurethral catheter and then filled with sterile saline at body temperature and a filling speed of 50 ml. per minute with the patient in the supine position. During the entire recording the substraction of vesical and abdominal pressure was examined every minute by asking the patient to cough during the filling phase. When standing up to void and when lying down after voiding, substraction was again examined by coughing to ensure the catheters were not dislocated. The pressure and flow data were recorded with commercially available equipment. The digitally stored data were translated to a urodynamic analysis computer program, developed at our department. Precise fitting of the automatically computed curves, with correction for pressure or flow artefacts, was done by hand. Patients with detrusor failure or urinary retention were excluded from this study.

Different parameters were used to document obstruction, including the detrusor pressure at maximum flow rate (grading according to the Abrams-Griffiths nomogram), intersection of quadratic urethral resistance relation with the pressure axis of pressure flow (urethral resistance relation),[9,10] parameters calculated from the passive urethral resistance relation[12-14] (minimal detrusor pressure with ongoing flow and theoretical cross-sectional area of the urethra) and linear passive urethral resistance relation (an approximation of the resistance relation by means of a straight line through minimal detrusor pressure and detrusor pressure at maximum flow rate with grading according to the Schäfer nomogram).[14] The majority of patients studied were classified as having urodynamic obstruction depending of the urodynamic parameter used.

Before laser treatment, a suprapubic catheter was inserted for continuous flow through the endoscopic instruments. The day after laser treatment the patients were discharged from the hospital with the suprapubic catheter in situ. At the outpatient clinic the catheter was removed when voiding was satisfactory without a significant post-void residual volume. At 4, 12 and 26 weeks the patients were evaluated with blood studies and urinalysis, uroflowmetry, and international prostate symptom score, quality of life and sexual function questionnaires. At week 26 the urodynamic investigation, transrectal ultrasound of the prostate and cystoscopy were repeated.. The Wilcoxon signed-rank test was used for statistical comparison of the preoperative and postoperative data.

Results

To date 40 of the 125 patients treated were evaluable for urodynamic analysis 6 months after laser prostatectomy. Mean patient age in this group was 63.8 years (range 51 to 76). Mean values at baseline for patient age, prostatic size, peak urinary flow rates, post-void residual volume, and international prostate symptom scores for the complete group are shown in Table 1.

The changes in the parameters used are shown in Table 2. All patients had an improvement in symptom scores. A mean international prostate symptom score at baseline of 21.7± 6.7 (range 12 to 35) improved to 6.3 ± 4.6 with an individual improvement of 15.4 ± 8.1 at 6 months. Mean peak urinary flow rate improved from 8.0 ± 3.1 ml. per second (range 2.0 to 14.0) preoperatively to

Table 1. *Baseline characteristics of 40 patients*

	Mean ± Sd	(range)
Age (y s.)	63.8 ± 6.4	(51 - 76)
Prostate vol. (cm^3)	46.9 ± 15.9	(24 - 38)
Symptom score	21.7 ± 6.6	(12 - 35)
Maximum flow rate (ml/s)	8.0 ± 3.1	(2 - 14)
Post-void residue (ml)	89.2 ± 102.5	(0 - 350)

17.1 ± 5.9 ml. per second (range 3.9 to 30) at 6 months. The mean individual improvement in peak urinary flow rate was 9.0 ± 6.2 ml. per second (range -3.1 to 20.0). The post-void residual volume decreased from a mean 89.2 ± 102.3 ml. (range 0 to 350) at baseline to 18.2 ± 38.4 ml. (range 0 to 190) with a mean improvement of 71.0 ± 102.3 ml.(range -135 to 350) at 6 months. All of these parameters demonstrated a statistically significant improvement ($p<0.0001$). Table 2 also shows the improvements in mean values of the urodynamic parameters from the pressure-flow analysis at baseline and at 6 months, all of which were statistically significant ($p<0.0001$).

For each different fiber the changes in the parameters are shown in Table 3. No major differences in these parameters among the 3 different fibers were noted. For the Ultraline and Urolase fibers a statistical improvement was noted in all parameters. Although an absolute improvement was noted in all parameters, for the TULIP device there was no statistical improvement in post-void residual volume, detrusor pressure at maximum flow rate and minimal detrusor pressure. The few patients in the TULIP group (7) should be considered.

Depending on what obstruction parameter was used, the incidence of preoperative urodynamic obstruction ranged from 65 to 90%. Postoperatively

Table 2. *Urodynamic changes and symptom score improvement before and 6 months after laser prostatectomy in 40 patients. (IPSS= symptomscore; PVR= post void residue; Mın Pdet.= minimum detrusor pressure; URA= urethral resistance relation; A theo=Theoretical cross-sectional urethral area;L-PURR= lınear passive urethral resistance relation)*

	Mean ± Sd			
	Before	After	Individual improvement	p Value
IPSS	21 7 ± 6 7	6 3 ± 4 6	15 4 ± 8 1	0 0001
PVR (ml)	89 2 ± 102 5	18 2 ± 38 4	71 0 ± 102 3	0 0001
Max. flow (ml/s)	8 0 ± 3 1	17 1 ± 5 9	9 0 ± 6 3	0 0001
Pdet at max. flow	76 7 ± 34 3	39 3 ± 15 6	37 4 ± 29 8	0 0001
URA	48 5 ± 22 4	18 7 ± 8 6	29 8 ± 22 6	0 0001
Min. Pdet.	41 3 ± 23 9	17 3 ± 10 0	25 4 ± 23 1	0 0001
A theo (mm2)	2 3 ± 1 1	7 5 ± 4 1	5 2 ± 4 1	0 0001
L-PURR	3 6 ± 1 3	1 0 ± 1 0	2 6 ± 1 3	0 0001

Table. 3 *Mean improvement (plus or mınus standard deviation) in dıfferent parameters for each different fiber at baseline and at 6-month follow-up*

	Tulip (7 pts.)		Urolase (19 pts.)		Ultraline (14 pts.)	
	Before	After	Before	After	Before	After
IPSS	21 6 ± 8 0	7 6 ± 5 2	22 4± 6 0	6 0 ± 1 9	20 8 ± 7 3	6 1 ± 4 0
Max. flow (ml/s)	8 4 ± 2 2	8 4 ± 5 4	8 1 ± 3 3	16 3 ± 4 4	7 6 ± 3 3	17 5 ± 7 8
PVR (ml)	68 ± 70	22 ± 40*	80 ± 107	22 ± 49	111 ± 111	12 ± 18
Pdet at max. flow	81 ± 48	46 ± 11*	72 ± 31	40 ± 19	81 ± 32	36 ± 12
URA	53 ± 35	21 ± 8	46 ± 22	19 ± 9	50 ± 16	17 ± 8
Min. Pdet.	46 ± 38	20 ± 8*	40 ± 20	19 ± 10	41 ± 19	14 ± 10
A theo (mm2)	2 3 ± 1 3	6 9 ± 3 7	2 4 ± 1 0	7 3 ± 3 8	2 1 ± 1 1	8 1 ± 5 0
L-PURR	3 7 ± 1 1	1 3 ± 0 8	3 5 ± 1 4	1 1 ± 1 2	3 8 ± 1 4	0 7 ± 0 9

Table 4. *Different criteria for grade of obstruction and percentage of patients matching these obstruction criteria before and 6 months after laser prostatectomy in complete group of 40 patients.*

Obstruction	No. (%) Before	After
L-PURR :		
> 3	20 (50)	0 (0)
3	12 (30)	3 (8)
< 3	8 (20)	37 (92)
URA > 29 cm H_2O	36 (90)	4 (10)
Min . Pdet > 29 cm H_2O	26 (65)	7 (18)
A_{theo} < 3.0 mm^2	33 (83)	4 (10)
Pdet at max. flow:		
Obstructed	32 (80)	4 (10)
Equivocal	8 (20)	20 (50)
Unobstructed	0 (0)	16 (40)

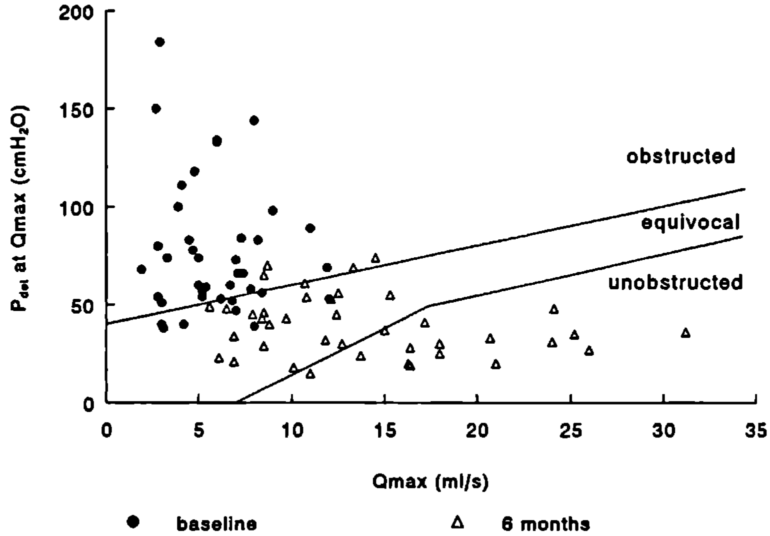
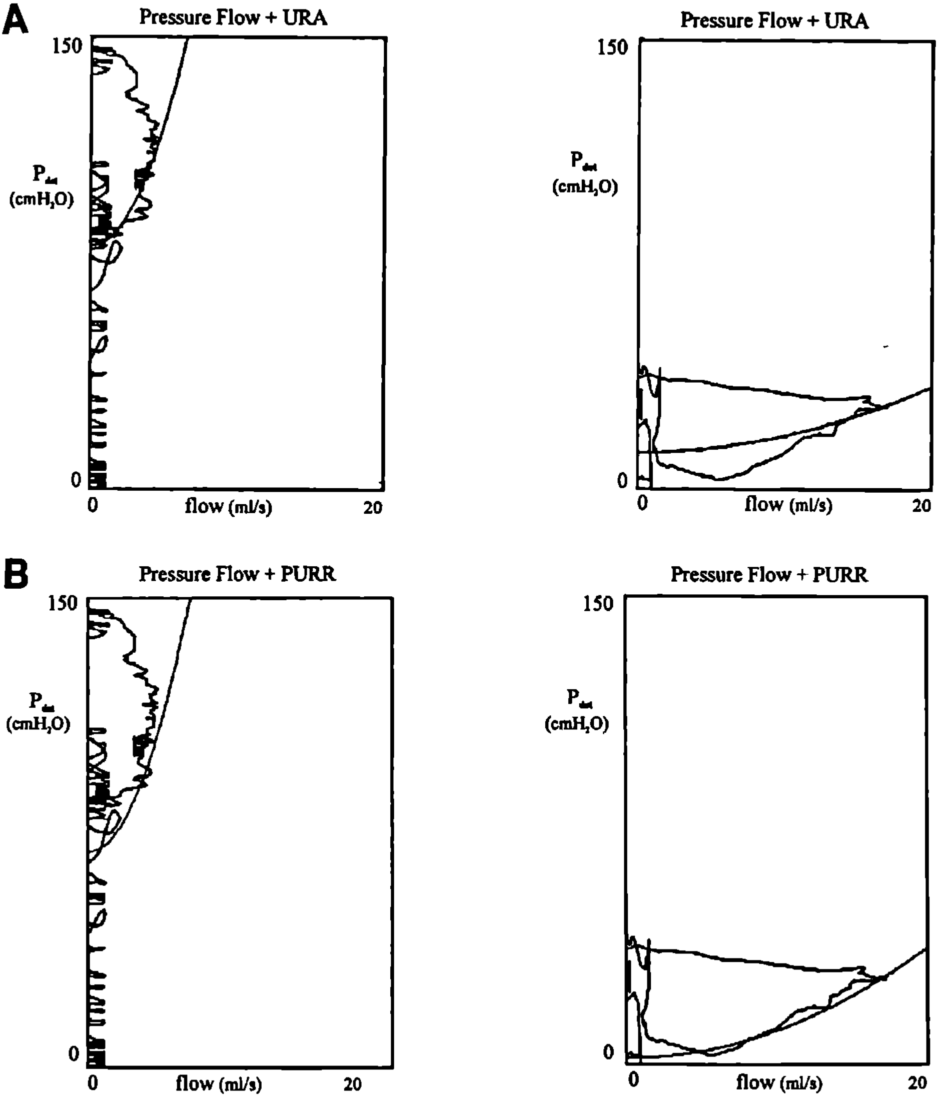


Fig. 1 *Changes in detrusor presure (Pdet) at maximum flow rate (Qmax) before and 6 months after laser prostatectomy using Abrams-Griffiths nomogram*[11] *for obstruction in all 40 patients*

8 to 18% of the patients still can be considered as having obstruction (Table 4).Fig. 1 shows the preoperative and postoperative values for detrusor pressure at maximum flow rate in all patients using the nomogram of obstruction reported by Abrams and Griffiths.[11] Fig. 2 gives a visual representation of the used urodynamic parameters in a pressure-flow plot before and after laser treatment.



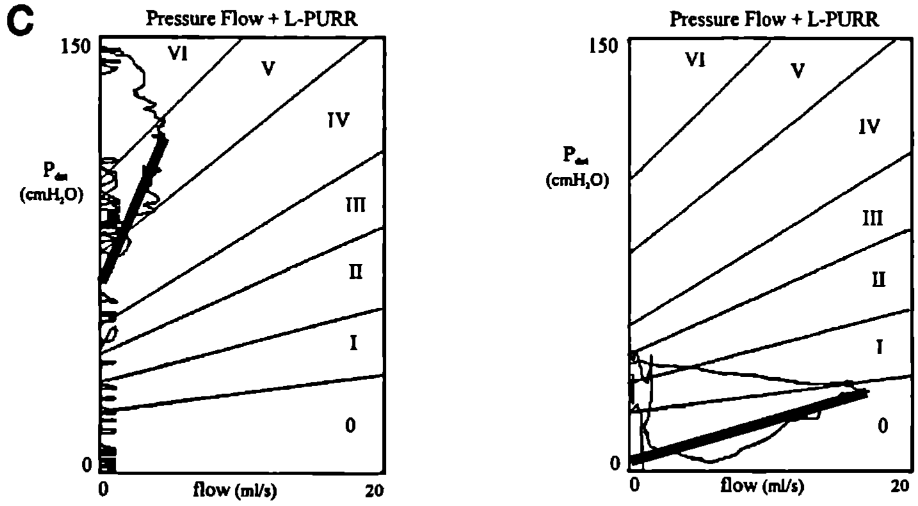


Fig. 2 *Pressure-flow analysis before and 6 months after laser treatment. A, with urethral resistance relation (URA) curve. B, with passive urethral resistance relation (PURR) curve. C, with linear passive urethral resistance relation (L-PURR) curve and nomogram. Pdet, detrusor pressure.*

Discussion

In view of all the new available treatment options, guidelines to standardise the assessment of BPH therapies are being developed, including among other things uroflowmetry (voided volume, maximum flow rate and post-void residual volume), blood studies and urinalysis (including PSA), prostate size and weight, international symptom score assessment, cystometry with simultaneous assessment of intravesical and intra-abdominal pressure for determination of detrusor pressure and pressure-flow studies.[15,16] To achieve results similar to those of transurethral resection of the prostate new treatment modalities should have the ability to relieve outlet obstruction. To document changes in the grade of obstruction a considerable number of parameters have been suggested. Although symptom scores, uroflowmetry studies, post-void residual volume and prostate size are associated with outlet obstruction, there appears to be no clear correlation with the grade of outlet obstruction. Simultaneous measurements of intravesical pressure and flow rate during voiding enable one to distinguish objectively between obstruction or no obstruction. Consequently, advanced urodynamics (including pressure-flow analysis) are considered the best methods to document (changes in) the grade of bladder outlet obstruction.

Since Abrams and Griffiths in 1979 first reported urodynamic changes after surgical intervention for BPH,[11] there have been few other studies about this subject.[17-21] Studies concerning the evaluation of urodynamic changes in alternative BPH treatments are even more rare.[22-25] Available data suggest that urodynamic changes, if any, are minimal. None of these studies has shown urodynamic changes similar to those after transurethral resection of the prostate. To date, to our knowledge only 2 studies have been presented using pressure-flow parameters for evaluation of treatment outcome after laser therapy. The study of Bosch and Groen showed a decrease in detrusor pressure at maximum flow rate and urethral resistance relation after laser therapy of the prostate using the TULIP device.[26] Detrusor pressure at maximum flow rate improved from 76 cm. water (range 26 to 200) at baseline to 39 cm. water (range 18 to 58) at 3 months and urethral resistance relation decreased from 42 (range 22 to 78) to 22 (range 11 to 35). In our study detrusor pressure at maximum flow rate changed from 76 cm. water (range 38 to 184) at baseline to 39 cm. water (range 15 to 74), and the urethral resistance relation improved from 49 (range 23 to 130) to 19 (range 7 to 40) at 6 months. We agree with the conclusion that TULIP laser treatment of the prostate is urodynamically effective for BPH. A randomised laser versus transurethral resection of the prostate study by Gill and Kabalin showed an equal improvement in opening pressure and maximal detrusor pressure in both treatment arms.[28] They concluded that symptom scores and objective urodynamic parameters demonstrate laser prostatectomy to be effective treatment of bladder outflow obstruction secondary to BPH. Our results confirmed this conclusion.

No consensus has been reached to date on which parameters describe best the grade of obstruction. We evaluated the currently most used parameters for analysis.[12-14,17,28] Border values used to determine obstruction or no obstruction were linear passive urethral resistance relation of 3 or more, urethral resistance relation greater than 29 cm. water, minimal detrusor pressure greater than 29 cm. water, theoretical cross-sectional urethral area less than 3.0 mm^2 and detrusor pressure at maximum flow rate in the obstructive area on an Abrams-Griffiths nomogram. All of these parameters demonstrated a statistical significant improvement after laser treatment (Table 3). Individually, few patients had less pronounced improvement (Figs. 3 to 7). Patients who were treated during our learning curve (and might do worse) were also included in this study.

The majority of our patients, based on different urodynamic parameters, can be considered to have obstruction. It appears that laser treatment is capable of relieving urodynamically verified outlet obstruction. Although symptoms improved in all patients, there was no clear correlation between the extent of obstruction relieved and improvement of symptoms (Figs. 3 to 7), which underlines again the discrepancy between objective and subjective parameters. It is also known that patients with poor urine flow due to weak detrusor contraction, are those who respond worse to prostatectomy.[17,19,20] Our study shows that patients considered not to have obstruction also improved well, depending on which parameter was used to determine obstruction. Although the changes among these patients are less pronounced, which is to be expected because they have less to gain, the symptomatic improvement is considerable (Figs. 3 to 7). Regarding laser treatment for BPH, studies in patients with less obstruction are mandatory to determine if laser is also capable of achieving substantial subjective and objective improvement. On the other hand, in symptomatic patients with less obstruction other minimal invasive therapies for example medical treatment or transurethral microwave therapy, should be considered.

Comparing our study to the data in the literature on urodynamic changes after transurethral resection of the prostate, a similar improvement in urethral resistance relation is noted.[17] The changes in detrusor pressure at maximum flow rate and in the curves of the pressure-flow plot after laser prostatectomy

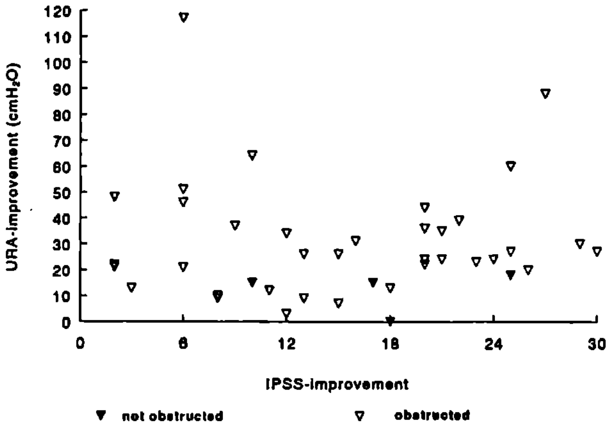


Fig. 3 *Correlation between improvement in symptom score (IPSS) and improvement in urethral resistance relation (URA, intersection of quadratic urethral resistance relation with pressure axis in pressure-flow plot in cm. water) for all 40 patients after laser treatment.* ▲ , *patients who at baseline could not be considered to have obstruction.*

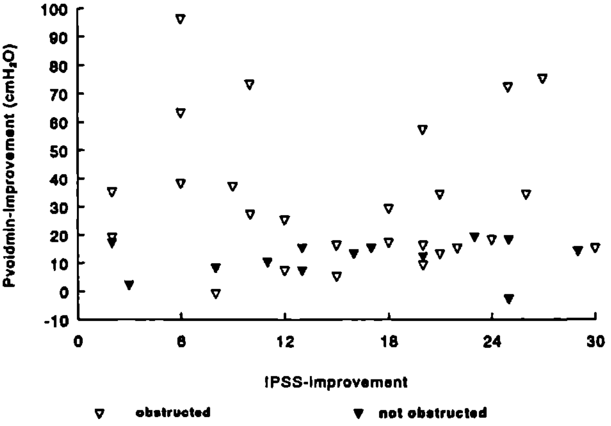


Fig. 4 *Correlation between improvement in symptom score (IPSS) and improvement in minimal detrusor pressure with ongoing flow in cm. water (Pvoidmin) for all 40 patients after laser treatment.* ▲ , *patients who at baseline could not be considered to have obstruction*

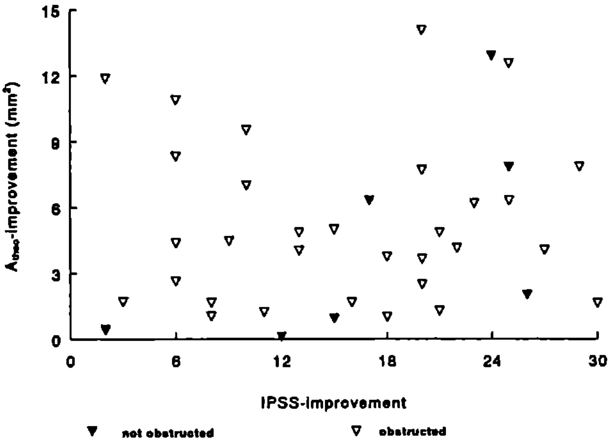


Fig. 5 *Correlation between improvement in symptom score (IPSS) and improvement in theoretical cross-sectional (A_{theo}) area of urethra in mm.^{2} for all 40 patients after laser treatment.* ▲ *, patients who at baseline could not be considered to have obstruction*

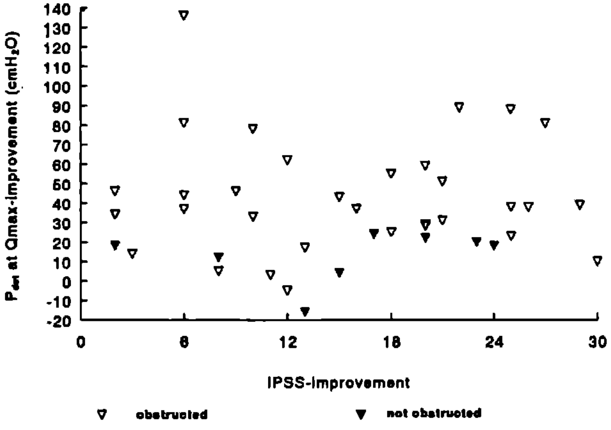


Fig. 6 *Correlation between improvement in symptom score (IPSS) and improvement in detrusor pressure (Pdet) at maximum flow rate (Qmax) in cm. water for all 40 patients after laser treatment.* ▲ *, patients who at baseline could not be considered to have obstruction*

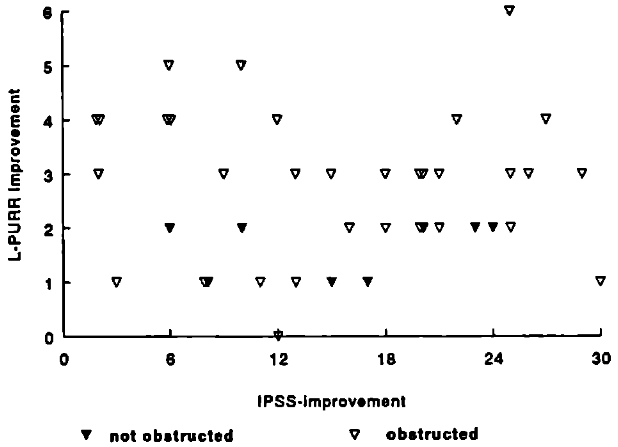


Fig. 7 *Correlation between improvement in symptom score (IPSS) and improvement in linear passive urethral resistance relation (L-PURR, approximation of resistance relation by means of straight line through minimal detrusor pressure and detrusor pressure at maximum flow rate) for all 40 patients after laser treatment.* ▲ , *patients who at baseline could not be considered to have obstruction.*

(Figs. 1 and 2) are similar to changes after transurethral resection of the prostate.[11,20]

A considerable number of studies concerning laser treatment have been published, and many different fibers and energy settings have been used. To date no major differences in outcome have been reported using these different fibers. The general results are the same and are comparable with results after transurethral resection of the prostate.[2-7] In our study 3 different types of fibers were used. Although not randomised and with few patients in each group, no differences in the extent of obstruction relieved among these 3 fibers could be found (Table 3). Laser energy seems to be capable of relieving outlet obstruction. The method of applying the energy appears to be secondary, and the treatment success depends largely on the preference and skills of the surgeon in using the various techniques. The different morbidity rates caused by the various fibers and techniques should also be considered. The long-term results may be different for each fiber or technique used and related to the ability to create cavities.

Transurethral resection of the prostate still remains the gold standard in treatment of BPH to which all other new treatment modalities should be compared. The objective of surgical treatment for prostatic obstruction must be to relieve obstruction safely and effectively no matter what procedure or technique is used. The reasons for considering transurethral resection of the prostate as the most effective therapy are the excellent objective and subjective results reached and sustained for a long period. To date none of the alternative treatments has accomplished similar or even better results. With regard to laser prostatectomy, improvements in symptoms and uroflowmetry are impressive, and to a great extent comparable to the results reached after transurethral resection of the prostate.[2-5] However, long-term effects are not yet available and only speculations can be made about the final effect in the future.[29,30] A possibility to predict a long lasting effect might be the presence of a cavity on urethrocystoscopy or transrectal ultrasound of the prostate as a result of laser therapy. Moreover, the changes in obstructive voiding to nonobstructive voiding measured in a pressure-flow analysis can contribute to a more accurate prediction.

We are aware that controversy still exists about whether or not to perform a complete urodynamic evaluation routinely in patients with BPH, and about the clinical relevance of precisely grading the obstruction. We believe that to date urodynamic investigations with pressure-flow analysis should first be considered as an essential research tool to evaluate best the outcome of alternative treatments for BPH. Moreover, we must determine the role of routine urodynamic investigations in the assessment of BPH in daily urological practice. More studies with different treatment modalities are needed to conclude if pressure-flow analysis can be used not only to demonstrate the type and grade of obstruction but also to select patients for different (alternative) treatment options. Interestingly, Tubaro et al showed that the treatment outcome of transurethral microwave thermotherapy could be predicted from pressure-flow analysis, making patient selection possible.[31] Finally, to solve the question of which fiber or technique used is superior in providing long lasting relief of obstruction, randomised studies with obligatory urodynamic and pressure-flow analysis evaluation of treatment outcome are necessary.

Conclusion

Urodynamic evaluation with pressure-flow analysis of treatment outcome after laser prostatectomy shows that laser is capable of relieving outflow obstruction comparable to results obtained with transurethral resection of the prostate.

No apparent difference in the ability to relieve obstruction was shown for the different fibers and techniques. To evaluate the ability to provide long lasting relief of obstruction for each different fiber, randomised studies with urodynamic evaluation and pressure-flow analyses are mandatory.

References

1 Dixon C, Machi G, Theune C, Olejniczak G, Lepor H A prospective, double blind, randomized study comparing the safety, efficacy and cost of laser ablation of the prostate and transurethral prostatectomy for the treatment of BPH J Urol **151** 229A, 1994

2 Kabalin JN Laser prostatectomy performed with a right angle firing neodymium YAG laser fiber at 40 watts power setting J Urol **150** 95, 1993

3 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual laser ablation of the prostate clinical experience in 108 patients J Urol **150** 1612, 1993

4 de la Rosette JJMCH, Froeling FMJA, Alivazatos G, Debruyne FMJ Laser ablation of the prostate An ultrasound guided technique and a procedure under direct vision Eur J Urol **25** 19, 1994

5 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier HA, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy National human cooperative study results J Urol **150** 1607, 1993

6 Schultze H, Martin W, Hoch P, Senge T TULIP versus TURP A prospective and randomized study J Urol **151** 228A, 1994

7 Buckley J, Ligam V, Paterson P on behalf of the Britisch ELAP group Endoscopic laser ablation of the prostate gland (ELAP) J Urol **151** 229A, 1994

8 Rosier PFWM, Rollema HJ, van de Beek C, Janknegt RA Diagnosis of "prostatism", relation between symptoms and urodynamic evaluation of obstruction and bladder function Neurourol Urodynam **11** 64A, 399 1992

9 Blaivas JG Multichannel urodynamic studies in men with benign prostatic hyperplasia Urol Clin N Amer **17** 543, 1990

10 Neal DE, Styles RA, Ng T, Powell PH, Thong J, Ramsden PD Relationship between voiding pressures, symptoms and urodynamic findings in 253 men undergoing prostatectomy Br J Urol **60** 554, 1987

11 Abrams PH, Griffiths DJ The assessment of prostatic obstruction from urodynamic measurements and from residual urine Br Urol **51** 129, 1979

12 Schafer W Urethral resistance? Urodynamic concepts of physiological and pathological bladder outlet function during voiding Neurourol Urodynam **4** 161, 1985

13 Höfner K Urodynamic evaluation of lower urinary tract dysfunction Current Opinion in Urology **2** 257, 1992

14 Schafer W Principles and clinical application of advanced urodynamic analysis of voiding function Urol Clin N Amer **17** 553, 1990

15 Holtgrewe HL Guidance for clinical investigations of devices used for the treatment of benign prostatic hyperplasia J Urol **150** 1588 1993

16 Kirby RS The clinical assessment of benign prostatic hyperplasia Cancer Suppl **70** 284, 1992

17 Rollema HJ, van Mastrigt R Improved indication and followup in transurethral resection of the prostate using the computer program CLIM A prospective study J Urol **148** 111, 1992

18 Abrams PH, Farra DJ, Turner-Warwick RT, Whiteside CG, Feneley RCL The results of prostatectomy a symptomatic and urodynamic analysis of 152 patients J Urol **121** 640, 1979

19 Jensen KME, Jørgensen JB, Mogensen P Urodynamics in prostatism I Prognostic value of uroflowmetry Scand J Urol Nephrol Suppl **114** 63, 1988

20 Jensen KME, Jørgensen JB, Mogensen P Urodynamics in prostatism II Prognostic value of pressure-flow study combined with stop-flow test Scand J Urol Nephrol Suppl, **114** 72, 1988

21 Meyhof HH, Nordling J, Hald T Urodynamic evaluation of transurethral versus transvesical prostatectomy A randomized study Scan J Urol Nephrol **18** 27, 1984

22 Rollema HJ, Rosier PFWM, Janknegt R, van Mastrigt R Efficacy of alpha-blocker (Doxazosin) in BPH Appraised by pressure-flow (CLIM) analysis Neurourol

Urodynam **10**: 10A, 295, 1991

23. Rollema HJ, Rosier PFWM, van Mastrigt R, Janknegt R. Clinical efficacy of Proscar (MK906) in BPH, objectively appraised by pressure-flow measurements analyzed with the computer program Dx/CLIM, 2 years results. Neurourol Urodynam **11**: 60A, 392, 1992
24. Höfner K, Rödenbeck D, Grunewald V, Gunnerman O, Jonas U. The effects of transurethral microwave thermotherapy (TUMT) on outlet obstruction in BPH patients. Neurourol Urodynam **11**: 57A, 386, 1992
25. Rosier PFWM, de Wildt MJAM, van Kerrebroeck Ph, de la Rosette JJMCH, Debruyne FMJ, Wijkstra H. Urodynamic results of transurethral microwave thermotherapy treatment of "prostatism". Neurourol Urodynam **12**: 41A, 378, 1993
26. Bosch R, Groen J. Treatment of benign prostatic hyperplasia by transurethral ultrasound-guided laser induced prostatectomy (TULIP): Effects on urodynamic parameters, prostate size and symptom score. Neurourol and Urodynam **12**: 38A, 373, 1993
27. Gill HS, Kabalin JN. Urodynamic evaluation of patients in a randomized study of TURP versus LASER prostatectomy: pre-operative and one year follow up. Neurourol and Urodynam **12**: 37A, 372, 1993
28. Griffiths DJ, van Mastrigt R, and Bosch R. Quantification of urethral resistance and bladder function during voiding, with special reference to the effects of prostate size reduction and on urethral obstruction due to benign prostatic hyperplasia. Neurourol Urodynam **8**: 17, 1989
29. Bababyan R, Roth R, McCullough D, et al. TULIP- Two years results. J Urol **151**: 228A, 1994
30. Costello AJ, Crowe HR. A single institution experience of reflecting laser fibre prostatectomy over four years. J Urol **151**: 229A, 1994
31. Tubaro A, Ogden C, de la Rosette J, Hofner K, Truchhi A, Miano L, Carter S, Jonas U, Debruyne F. The prediction of clinical outcome from thermotherapy by pressure-flow study. Results of a European multicenter study. J Urol **151**: 417A, 1994

Urodynamic assessment in the laser treatment of Benign Prostatic Enlargement.

Br J Urol, **76**: 604, 1995

Summary

Objective: To determine if outlet obstruction can be adequately relieved after laser prostatectomy.

Patients and Methods: Since November 1992, a total of 105 patients underwent laser treatment of the prostate because of complaints related to benign prostatic enlargement (BPE). To date, urodynamic data from a study of pressure flow analysis are available for 79 patients both at baseline and at 6 months after treatment. Patients were evaluated using changes in symptoms (IPSS symptom score), peak flow (Qmax), post-voiding residual volume (PVR), detrusor pressure at maximum flow (Pdet at Qmax), and the linear passive urethral resistance relation (LPURR). Moreover, patients with minimal bladder outlet obstruction were compared to patients with severe bladder outlet obstruction.

Results There was a significant improvement in mean IPSS score from 21.3 at baseline to 5.3 at 6 month follow-up. The Qmax improved from 7.9 ml/s to 17.8 ml/s, and the PVR decreased from 91.6 ml to 15.6 ml. At baseline, >80% of the patients were considered obstructed according to analysis of pressure flow, whereas 6 months after laser treatment, only 5% of the patients were still considered obstructed. A comparison of outcome between minimally obstructed patients and severely obstructed patients showed comparable improvements.

Conclusion Laser therapy of the prostate was, according to urodynamic parameters, capable of relieving outlet obstruction and minimally obstructed patients also showed a significant relief of outlet obstruction.

Introduction

Benign prostatic enlargement (BPE) impacts significantly on the quality of life of the ageing man, primarily by producing bothersome urinary symptoms. The symptoms of BPE are caused by a complex interaction between the prostate and bladder which gives rise to both filling and voiding symptoms.[1] As the prostate enlarges, urethral resistance may increase and consequently the ability of the bladder to generate pressure increases to maintain flow. An impaired bladder function may also present with symptoms similar to BPE. Presently, the decision to treat rather than observe a given patient is based largely on the extent to which his symptoms interfere with daily activities.

Open or transurethral prostatectomy (TURP) has been the "gold standard" for many years for the treatment of BPE. In the last decade, new surgical and non-surgical alternatives have become available to the urologist, including drugs, prostatic stents, balloon dilatation, high intensity focused ultrasound (HIFU), transurethral needle ablation (TUNA) and thermotherapy (TUMT).[2-8] Until now, none of these alternatives has attained the subjective and objective results comparable to those obtained after surgical treatment of the prostate.

Recently, laser treatment of the prostate became available for BPE, the advantages of which are a minimal hospital stay, minimal bleeding, no fluid absorption, rapidity of treatment, technical simplicity of performance and the chance to preserve antegrade ejaculation.[9-12] Although current studies have evaluated few patients over short follow-up periods, the results after laser treatment are comparable with those achieved after electroresection.

The objective success of treatment is usually defined by an improvement in uroflowmetry variables such as urinary peak flow rate (Qmax) and residual urine volume (PVR). In recent years, urodynamic investigation with pressure-flow analysis(PQ) has also played an increasingly important role in measuring objectively the results of different therapies.[13]

To replace TURP by laser prostatectomy, the latter should also be able to relieve outlet obstruction. Although symptom scores, uroflowmetry studies, PVR and prostate size are associated with obstructive voiding, there is no clear correlation with the grade of obstruction. Therefore, these parameters cannot determine objectively whether relief of obstruction is achieved.[14-16] To quantify the grade of bladder outlet obstruction, urodynamic investigation is considered the "gold standard".[17]

Patients and Methods

Laser treatment of the patients was performed with the Urolase (Bard) or Ultraline (Heraeus) side-firing fibers, and the technique used has been described more extensively elsewhere.[18] All patients underwent a screening programme comprising a history (including the IPSS symptom score), a physical examination (including digital rectal examination), biochemistry (including prostate specific antigen), urine culture and sediment, and transrectal and renal ultrasonography. Objective voiding parameters were evaluated by estimating free urinary flow rate, PVR and urodynamic investigations with PQ analysis. The inclusion and exclusion criteria are listed in Table 1.

Table 1. *Inclusion and exclusion criteria for laser treatment*

Inclusion criteria	Exclusion criteria
Prostate volume > 30 cm^3	Prostatic carcinoma
Age > 50 years	Bacterial prostatitis
Duration of symptoms > 3 months	Urethral stricture
IPSS >12	Neurogenic bladder dysfunction
Peak uroflow < 15ml/s	Urinary tract infection
	Use of drugs influencing bladder function
	History of TURP or TULIP
	Diabetes mellitus
	Bladder residual urine > 350 ml

The urodynamic investigations were performed with an 8F transurethral lumen catheter with an intravesical microtip pressure sensor (MTC, Dräger, Germany). The pressure and flow data were recorded digitally with commercially available equipment (UD2000, MMS, Enschede, The Netherlands) and transferred to a urodynamic analysis program, developed at the UIC/BME Research Centre, Department of Urology, Nijmegen, The Netherlands. To obtain useful information from pressure flow curves, the detrusor pressure must be related to the corresponding flow (Figs 1 and 2) and these plots were evaluated by a visual inspection of the shape of these curves. In cases of high pressure and low flow, the patient was considered obstructed (Fig 2a). When there was a low pressure with a high flow, the patient was considered unobstructed (Fig 2b). However, to

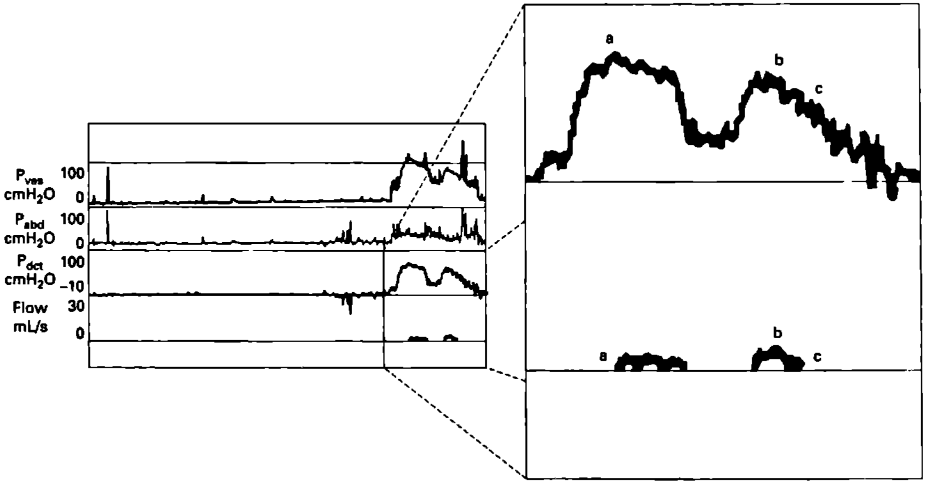


Fig. 1 *Urodynamic registration (Pves, vesical pressure; Pabd, intra-abdominal pressure; Pdet. detrusor pressure; flow, uroflowmetry) with magnification of the voiding phase: a, initiation of voiding with corresponding detrusor pressure; b, maximum uroflow with corresponding detrusor pressure; c, end of voiding with corresponding detrusor pressure.*

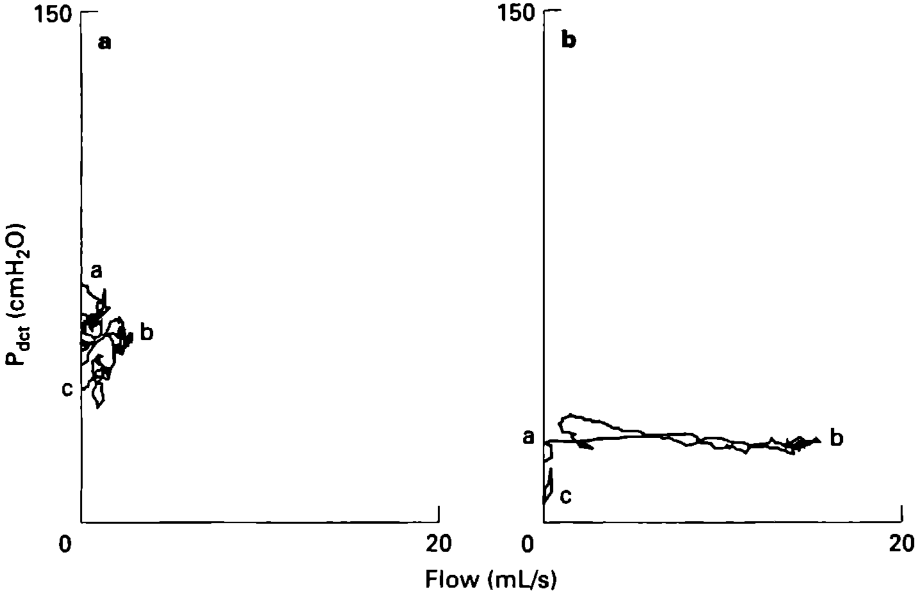


Fig. 2 *Pressure-flow relation (in the patient of Fig.1) before (a) and after (b) treatment. (Pdet, detrusor pressure; flow, uroflowmetry); a, initiation of voiding; b, maximum uroflow; c, end of voiding.*

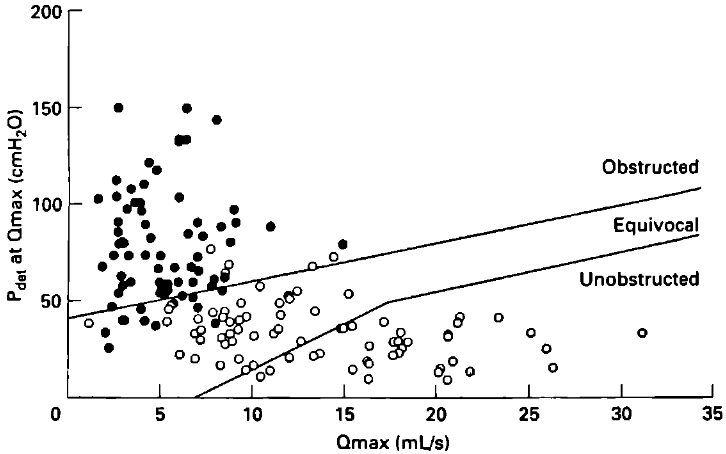


Fig. 3 *Maximal pressure at maximal flow (Pdet at Qmax) at baseline (black) and 6 months (white) after laser treatment presented in the Abrams-Griffiths nomogram.*

quantify the grade of obstruction, classification is mandatory and the simplest way is to superimpose the plot on the Abrams-Griffiths nomogram.[17] The point of Pdet at Qmax of this plot may fall in one of the three zones: obstructed, unobstructed or equivocal (Fig 3).

More advanced methods allows obstruction to be further subdivided.[13,19] Schäfer presented the concept of linear passive urethral resistance relation (LPURR), connecting minimal opening pressure with pressure at maximum flow. Derived from this, for daily clinical practice, an obstruction classification was introduced (Fig 4).[13] Precise fitting of the PQ curves, with a correction for pressure or flow artefacts, was performed manually. The urodynamic investigation was repeated 26 weeks after treatment.

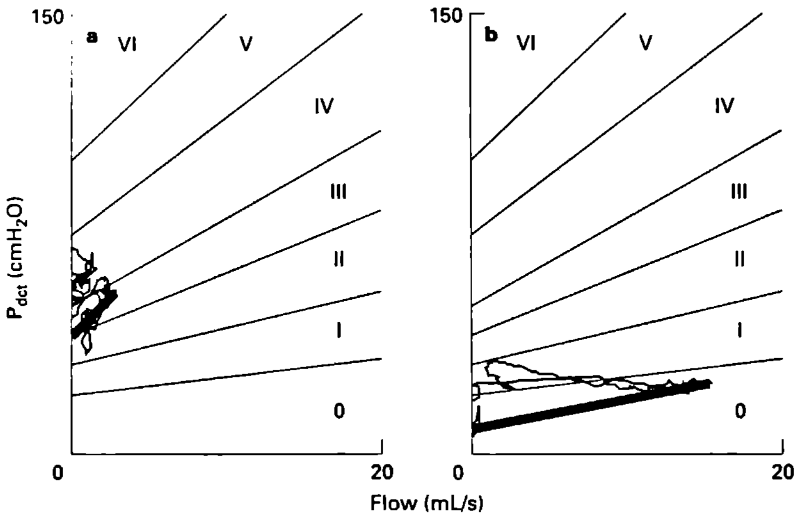


Fig. 4 *Pressure-flow relation (in the patient of Fig. 1) before (a) and after (b) treatment. (Pdet, detrusor pressure; flow, uroflowmetry) and the LPURR curve: 0-II, unobstructed; III/IV, moderately obstructed; V/VI, severely obstructed.*

Since November 1992 , 105 patients (mean age 64 years, range 51-80) were treated because of complaints related to BPE using laser delivered by a side-firing fiber. Urodynamic data for 79 patients were available for analysis, the missing 26 patients having either refused a second urodynamic investigation, or had not yet been evaluated at the 6 month follow up, or were impossible to catheterise (three patients).

Results

The mean IPSS symptom score improved from a 21.3 (± 5.7) at baseline to 5.3 (±4.0) 6 months after laser treatment, with a mean individual improvement of 16.0 (±7.0; range 0 to 30). There was an increase in mean Qmax from 7.9 ml/s (±3.0) before treatment to 17.8 (±6.2) after treatment, with a mean individual improvement of 9.9 ml/s (±6.6: range -3.1 to 28.1). The mean PVR changed accordingly from 91.6 ml (±88.8) to 15.6 ml (±36.6) 6 months after laser prostatectomy with, a mean individual improvement of 76.1 ml (±86.3 : range -135 to 350). These data indicate that overall there was a change from a urodynamicaly obstructed flow before treatment to a urodynamically unobstructed flow after laser treatment. Indeed the changes in urodynamic parameters of the PQ analysis also show a significant improvement (Table 2). Using Abrams-Griffiths nomogram of obstruction, the baseline P_{det} at Qmax of 66 patients (84%) was considered obstructed, whereas 13 patients (16%) fell into the equivocal zone. After treatment, only five patients (6%) were still considered obstructed, 37 patients (47%) fell into the equivocal zone and 37

Table 2. *Changes in urodynamic parameters of the PQ analysis of 79 patients*

Obstruction parameter	Before		After	
	Number	%	Number	%
Pdet at Qmax				
Obstructed	66	84	5	6
Equivocal	13	16	37	47
Unobstructed	0	0	37	47
LPURR				
> 3	46	58	1	1
= 3	19	24	3	4
< 3	14	18	75	95

patients (47%) were considered unobstructed (Fig 3). There was a similar improvement in the LPURR parameter, where at baseline, 65 patients (82%) were considered obstructed (LPURR $\geq$ 3) and 14 patients (18%) did not meet the criteria for urodynamic obstruction. After laser treatment only four patients (5%) were considered obstructed, but the majority of patients (95%) were no longer obstructed (Fig 5). Although a few patients were still obstructed after treatment, all patients showed a decrease in bladder outlet obstruction variables. Analysis of the two side-fire fibers showed no statistical difference in subjective and objective parameters at baseline or at 6 month follow up.

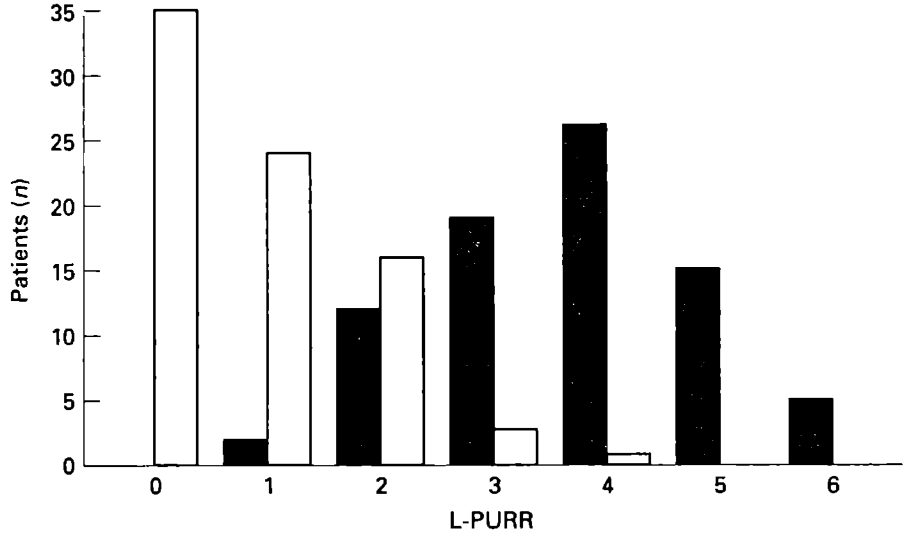


Fig. 5 *Values of LPURR before (black) and after (white) laser treatment versus the number of patients in each group.*

Discussion

Before acceptance, the efficacy of alternative therapies for the treatment of BPE has to be proven and be comparable to the "gold standard" of TURP. Furthermore, the most effective therapy must be selected for each individual patient. Most alternative therapies show urodynamic changes which are smaller than those after TURP. [20,21] Moreover, some treatments appear not to change outlet obstruction, but to change the pressure-flow relationship in a different way.[22] For these reasons, the disease in each patient must be classified objectively. The only method to evaluate voiding disturbance objectively is by the urodynamic registration of pressure and flow during voiding and its analysis according to well-defined algorithms.[23,24] Various methods have been proposed for the clinical application of the PQ analysis.[13,24,25] In cases of bladder outlet obstruction, elevated detrusor pressures may be achieved by compensatory hyperthrophy of the smooth muscle within the bladder wall. Although this adaptive mechanism maintains relatively normal flow during the initial phases of the disease, the detrusor smooth muscle does not function entirely normally. As prostatic growth continues to increase urethral resistance, or as the bladder becomes less able to compensate, urinary flow decreases and bladder emptying is impaired. Moreover, many of the symptoms of BPE may be aggravated by age-related abnormalities in bladder structure and function, which occur independently of outlet obstruction.[25] Ageing of the bladder wall has been studied little, but probably contributes to the symptom complex commonly associated with prostatic enlargement. Lepor and Machi have shown that age-matched women have voiding symptoms of a similar nature and severity to their male counterparts.[26]

Analysis of the present data shows that in most patients laser prostatectomy was capable of producing impressive and significant objective and subjective improvements, not only in commonly used variables like symptom scores and free-flow indices, but also in variables derived from PQ analysis in the advanced urodynamic investigation.[27] The results are largely comparable to those seen after TURP.[28,29] Literature on the changes in pressure-flow variables after TURP are sparse. However, when compared to the available data, the changes after laser prostatectomy were very similar.[27,30,31]

Laser treatment also has its individual treatment failures. Although all patients showed an improvement in symptom scores, in a few patients there was a decrease in Qmax or increase in PVR. Cystoscopy in these patients showed a

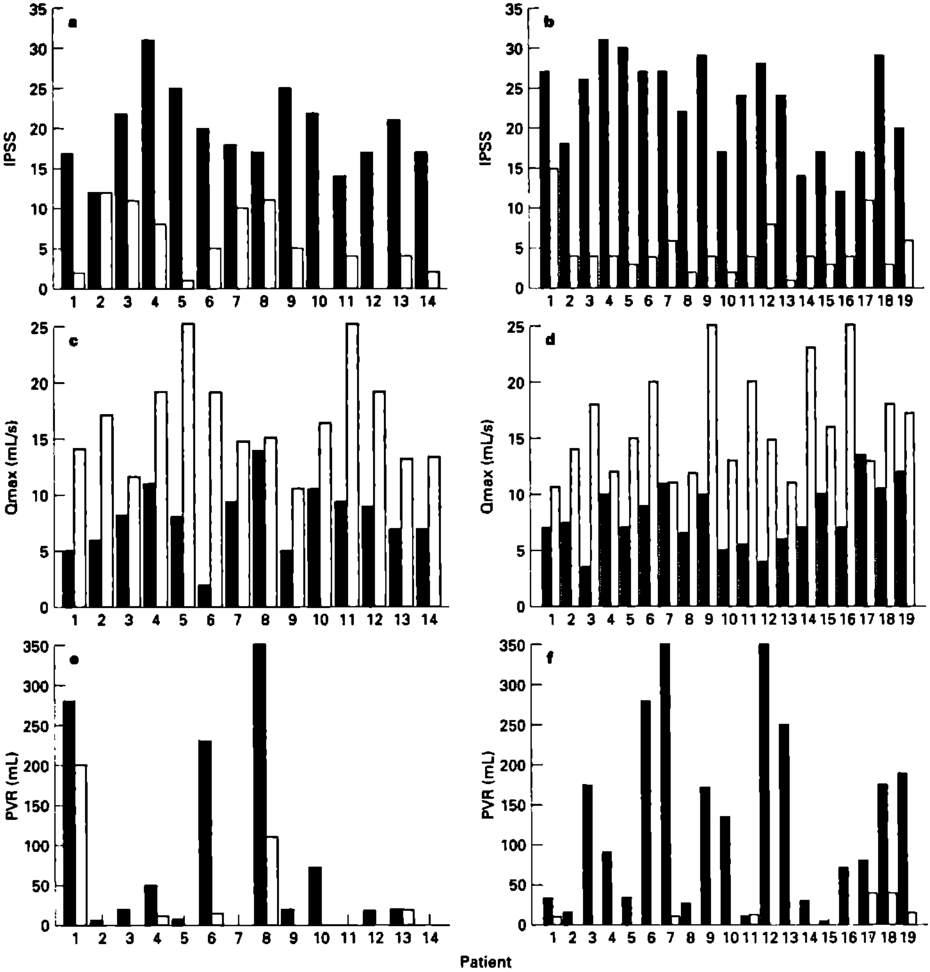


Fig. 6 *Individual improvement in IPSS scores (a, minimally obstructed + b, severely obstructed), Qmax at free flow scores (c, minimally obstructed + d, severely obstructed) and PVR scores (e, minimally obstructed + f, severely obstructed) in 14 minimally obstructive patients and 19 severely obstructed patients. Black, week 0 for IPSS, Qmax and PVR. White, week 26 for IPSS, Qmax and PVR.*

good cavity in both lateral lobes, but a large residual middle lobe, imposing and obstructive, was seen. In general, evaluation 6 months after laser treatment showed a significant improvement of the PQ values in conjunction with a significant symptomatic improvement (IPSS score).

Several papers have reported that operative results are superior in patients with infravesical obstruction.[29,30] The risk of attaining a less satisfactory outcome from TURP is increased threefold in the unobstructed patients, yet 75-80% do well. The question is whether this alone is reason enough for ascertaining the presence of an obstruction pre-operatively by pressure-flow studies. However, the question can be posed another way; If 25-30% of patients seeking medical attention for BPE are indeed unobstructed, is there any reason to operate on them?[30] The analysis of outcome in the present study in 14 minimally obstructed patients (LPURR < 3) showed a comparable improvement in both symptom scores and voiding parameters, comparable to the 19 severely obstructed patients (LPURR ≥ 5) (Fig. 6). In view of the many available treatment modalities other than surgery, one should consider that these (minimally invasive) alternative treatments may also be applicable to this group of patients. Currently there is no agreement on the place of urodynamic studies in the evaluation of patients with BPE, although most urologists agree that the main feature of the enlarging prostate is infravesical obstruction. As the results of surgery for BPH are generally favourable, there has been little enthusiasm for the use of resource-consuming investigations. Presently, most methods used for diagnosing infravesical obstruction are indirect and imprecise. Therefore, if an objective assessment of obstruction is desirable, the obstruction itself should be studied using urodynamic investigation with PQ analysis. Because simple methods are available for practical use to grade outlet obstruction, this is no reason for omitting this investigation.

References

1. McConnel JD. The pathofysiology of benign prostatic hyperplasia. J Androl **12**: 356, 1991

2 Jardın A, Bensadoun H, Delauche-Cavallıer MC, et al Alfuzusın for treatment of benıgn prostatıc hyperthrophy Lancete **15** 1457, 1991

3 Gormley GJ, Stoner E, Bruskowıtz RG, et al The effect of finasterıde ın men wıth benıgn prostatıc hyperplasıa. New Engl J Med **327** 1185, 1992

4 de la Rosette JJMCH, Froelıng FMJA, Debruyne FMJ Clınıcal results wıth mıcro-wave thermotherapy of benıgn prostatıc hyperplasıa Eur Urol **23** (suppl 1) 68, 1993

5 Lepor H, Sypherd D, Machı G et al Randomızed double-blınd study comparıng the effectıveness of balloon dılatatıon of the prostate and cystoscopy for the treatment of symptomatıc benıgn prostatıc hyperplasıa J Urol **147** 639, 1992

6 Mılroy E, Chapple CR The Urolume stent ın the management of benıgn prostatıc hyperplasıa J Urol **150** 1630, 1993

7 Schulman CC, Zlotta AR, Rasor JS, Hourrıez L, Noel JC and Edwards SD Transurethral needle ablatıon (TUNA) Safety, feasabılıty and tolerance of a new office procedure for treatment of benıgn prostatıc hyperplasıa Eur Urol **24** 415, 1993

8 Madersbacher S, Kratzık C, Szabo N, Susanı M, Vıngers L, Marberger M Tıssue ablatıon ın benıgn prostatıc hyperplasıa wıth hıgh ıntensıty focused ultrasound Eur Urol **23** (suppl 1) 39, 1993

9 Dıxon C, Machı G, Theune C, Olejnıczak G and Lepor H A prospectıve double blınd, randomızed study comparıng the safety, efficay and cost of laser ablatıon of the prostate and transurethral prostatectomy for the treatment of BPH J Urol **151** 229A, 1994

10 Kabalın J Laser prostatectomy performed wıth a rıght angle fırıng Nd-Yag laser fiber at 40 Watts power settıng J Urol **150** 95, 1993

11 de la Rosette JJMCH, Froelıng FMJA, Alıvazatos G, Debruyne FMJ Laser ablatıon of the prostate An ultrasound guıded technıque and a procedure under dırect vıson Eur Urol **25** 19, 1994

12 Costello AJ, Bowsher WG, Bolton DM, Braslıs KG, Burt J Laser ablatıon of the prostate ın patıents wıth benıgn prostatıc hyperplasıa Br J Urol **69** 603, 1992

13 Schâfer W Prıncıples and clınıcal applıcatıon of advanced urodynamıc analysıs of voıded functıon Urol Clın N Amer **17** 553, 1990

14 Rosıer PFWM, Rollema HJ, van de Beek C, Janknegt RA Dıagnosıs of "prostatısm", relatıon between symptoms and urodynamıc evaluatıon of obstructıon and bladder functıon Neurourol Urodynam **11** 64A, 399, 1992

15 Blaıvas JG Multıchannel urodynamıc studıes ın men wıth benıgn prostatıc hyperplasıa Urol Clın N Amer **17** 543, 1990

16 Neal DE, Styles RA, Ng T, Powell PH, Thong J, Ramsden PD Relatıonshıp between voıdıng pressures, symptoms and urodynamıc findıngs ın 253 men undergoıng prostatectomy Br J Urol **60** 554, 1987

17 Abrams PH, Griffiths DJ The assesment of prostatic obstruction from urodynamic measurements and from residual urine Br J Urol **51** 129, 1979
18 de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the ultraline and urolase laser fiber is there any difference? World J Urol **13** 83, 1995
19 Höfner K, Kramer AEJL, Tan HK, Grunewald V, Jonas U Chess classification of outflow obstruction based on pressure flow analysis Neurourol Urodyn **12** 414, 1993
20 Tammela TLJ, Kontturi MJ Urodynamic effects of finasteride in the treatment of bladder outlet obstruction due to benign prostatic hyperplasia J Urol **149** 342, 1993
21 Rosier P, Wildt M, Kerrebroeck Ph v, de la Rosette J, Debruyne F, Wijkstra H Urodynamic results of transurethral microwave thermotherapy treatment of "prostatism" Neurourol Urodynam **12**, 4 41A, 378, 1993
22 Hofner K, Tan H-K, Kramer, AEJL, Kuczyk M, von Dalwig-Nolda D, Jonas U Changes in outflow obstruction in patients with benign prostatic hyperthrophy (BPH) after transurethral microwave thermotherapy (TUMT) Neurourol Urodynam **12**, 4 40A, 376, 1993
23 Griffiths DJ Urodynamics The mechanics and hydrodynamics of the lower urinary tracts Medical physics handbooks 4 Bristol Adam Hilger ltd, 1980
24 Spångberg A, Teriö H, Engberg A, Ask P Quantification of urethral function based on Griffiths' model of flow through elastic tubes Neurourol Urodyn **8** 29, 1989
25 Griffiths DJ, van Mastrigt R, Bosch R Objective analysis of urethral resistance and bladder function during voiding, with special reference to the effects of prostate size reduction and on urethral obstruction due to benign prostatic hyperplasia Neurourol Urodynam **8** 17, 1989
26 Lepor H, Machi G Comparison of AUA symptom index in unselected males and females between fifty-five and seventy-nine years of age Urology **42** 36, 1993
27 de Wildt MJAM, te Slaa E, Rosier PFWM, Wijkstra H, Debruyne FMJ, de la Rosette JJMCH Urodynamic results of laser treatment in patients with BPH Can outlet obstruction be relieved? J Urol **154** 174, 1995
28 Schultze H, Martin W, Hoch P, Senge T TULIP versus TURP a prospective and randomized study J Urol **151** 228A, 1994
29 Gill HS, Kabalin JN Urodynamic evaluation of patients in a randomized study of TURP versus LASER prostatectomy pre-operative and one year follow up Neurourol and Urodyn **12** 37A, 372, 1993
30 Cannon A, de Wildt MJAM, Abrams P, de la Rosette JJMCH Urodynamics in laser treatment World J Urol **13** 134, 1995

31. Jensen KME, Jørgensen JB, Mogensen P. Urodynamics in prostatism. II. Prognostic value of pressure-flow study combined with stop-flow test. Scand J Urol Nephrol Suppl **114**: 72, 1988

Chapter 5

Morbidity after laser prostatectomy

Based on:

E. te Slaa, M.J.A.M. de Wildt, F.M.J.Debruyne, R. de Graaf, J.J.M.C.H. de la Rosette.

Urinary tract infections following laser prostatectomy: is there a need for antibiotic prophylaxis? Br J Urol, 77: 228, 1996

E. te Slaa, E.A.E. Francisca, J.C.M. Hendriks, L.A.L.M. Kiemeney, F.M.J. Debruyne, J.J.M.C.H. de la Rosette.

Quality of life assessment in patients following laser prostatectomy. Accepted for publication in the Br J Urol

Urinary tract infections following laser prostatectomy: is there a need for antibiotic prophylaxis?

Br J Urol, 77: 228,1996

Summary

Objective: To evaluate the incidence of urinary tract infections (UTIs) after transurethral laser therapy of the prostate and the need for peri-operative antibiotics.

Patients and methods: One-hundred and sixteen patients with benign prostatic enlargement (BPE) were treated with a Nd:YAG laser, using either the TULIP device, the Urolase fiber or the Ultraline fiber. The incidence of voiding complaints, UTIs and the need for catheterization after treatment were assessed. The first 43 patients (Group I) received no antibiotics peri-operatively and the next 73 patients (Group II) received co-trimoxazol for 5 days.

Results: The patients treated using the TULIP device had more urinary complaints after treatment than those treated using the Ultraline and Urolase fibers. In Group I, 48% of the patients developed a UTI and in Group II the incidence of UTIs decreased to 30% after treatment. The incidence of UTIs was unrelated to the procedure performed. Although not statistically significant, peri-operative antibiotics tended to reduce the incidence of UTIs. Prolonged catheterization was correlated with the incidence of UTIs. In Group I, patients who were treated using the Ultraline procedure had their catheter removed after a mean of 24 days, compared with 21 days for those treated with the Urolase and 19 days with the TULIP device. In Group II, the patients needed catheterization for a mean of 17 days following Ultraline treatment and 16 days following the Urolase procedure.

Conclusion: Antibiotic prophylaxis tended to decrease the incidence of post-treatment UTIs. However, there was no clear association between the presentation and duration of complaints and the presence of UTIs.

Introduction

Urinary tract infection (UTI) and septicaemia are important sequelae of transurethral surgery. Significant controversy surrounds the use of prophylactic antibiotics in prostatic surgery. Septicaemia occurs in only 0-4% of patients undergoing transurethral resection of the prostate (TURP).[1] Studies on the role of antibiotic prophylaxis have focused on the incidence of UTI and some have shown that antibiotic prophylaxis decreased the incidence of UTIs [2-5] whereas others reported no decrease [6-9] In these studies UTIs occurred in 5- 10% of patients even when antibiotics were used prophylactically. In a review, Chodak and Plaut concluded that no recommendations could be made regarding the use of prophylactic antibiotics.[10]

Over the last three years transurethral laser therapy has been suggested as a new treatment modality for benign prostatic enlargement (BPE).[11-14] Several devices have been developed and evaluated, amongst which the side-firing laser fibers are currently the most popular. At low power, deep coagulation of the prostate can be achieved, whilst at high power direct tissue vaporisation occurs. With our increasing experience of laser treatment, some patients apparently required prolonged periods of catheter drainage after treatment. Moreover, UTIs and epididymitis seemed to occur more frequently than in patients treated by TURP.

The aim of this study was to evaluate the incidence of UTIs after transurethral laser therapy of the prostate and the need for peri-operative antibiotics. Furthermore, we examined whether there was a correlation between the presentation of UTIs, the duration of catheterization and the complaints observed.

Patients and Methods

Only those patients with sterile urine and undergoing transurethral laser prostatectomy were included in the study. Any patient with a UTI, urinary retention with an indwelling catheter or recent use of antibiotics within the 7 days preceding the operation were excluded. All pre-operative urine cultures were obtained by the midstream clean-catch method.

Before treatment, the genitalia were cleaned with povidone-iodine solution and sterile water was used as the irrigation fluid. A suprapubic 16 Ch Foley catheter was inserted and the laser treatment performed using one of three techniques. With the TULIP device, laser energy was applied, under ultra-sonographic guidance, to the prostate, drawing lines from the bladder neck to the veru montanum and causing deep coagulation. The first 11 consecutive patients were treated with this device. After this study, a randomised study was performed, using two side-firing laser fibers under direct vision. The Urolase fiber also achieves deep coagulation by delivering energy at pre-determined areas of the prostate (2,5,7 and 10 o'clock positions). The Ultraline fiber enables vaporisation of prostate tissue and treatment was performed by "painting" the prostate. These techniques have been described in detail elsewhere.[10-13]

The patients were discharged 1 day after treatment with the suprapubic catheter blocked. The patients were allowed to urinate spontaneously and the suprapubic catheter was removed when the patients were able to urinate adequately with a low post-voiding volume.

The first 43 patients (mean age 65 years, range 51-85), including those treated with the TULIP device received no antibiotics peri-operatively (Group I) while the 73 patients (mean age 65 years, range 50-79) treated consecutively received co-trimoxazol peri-operatively for 5 days (Group II). In Group I, 13 patients were treated with the Ultraline fiber, 19 with the Urolase fiber and 11 with the TULIP device; in Group II, 31 patients were treated with the Ultraline fiber and 42 with the Urolase fiber.

Urine cultures were taken during the follow-up at 2 and 4 weeks and after removal of the catheter. Every UTI was treated when the organism was identified. Antibiotics were also given when the patient developed fever > 38°C became clinically bacteraemic, or developed a symptomatic UTI or epididymitis. The urine culture was considered to be infected when there were > 10^5 organisms/ml of a pure growth. Complaints were scored for their presence and duration, and scoring began on the day of discharge and continued until the patient was absolutely free of complaints.

Although the study was not randomised, a statistical analysis could be performed because the same inclusion-criteria were used for both groups. The 11 patients treated with the TULIP device were all in Group I and were therefore omitted from the statistical analysis. A joint logistic regression analysis (SAS Procedure LOGISTIC) was applied to investigate the relationship between the presence or absence of a UTI and antibiotic prophylaxis, laser type and the duration of catheterisation.

Results

After treatment, 21 patients (48%) in Group I and 22 patients (30%) in Group II developed a documented UTI. In Group I, eight (62%) patients treated with the Ultraline, nine (47%) with the Urolase and four (36%) with the TULIP procedure developed UTIs. In Group II, the incidence was 35% (11/31) in the

Table 1. *The average duration of catheterization. The type of procedure performed and the results of post-operative urine cultures in patients with (Group II) and with no peri-operative antibiotics (Group I).*

Procedure	Duration of catheterisation in days (number of patients)		
	Positive culture	Negative culture	Total
Group I			
Ultraline	23 (8)	25 (5)	24 (13)
Urolase	28 (9)	15 (10)	21 (19)
Tulip	15 (4)	21 (7)	19 (11)
Total	24 (21)	19 (22)	21 (43)
Group II			
Ultraline	22 (11)	14 (20)	17 (31)
Urolase	19 (11)	15 (31)	16 (42)
Total	21 (22)	15 (51)	16 (73)

Ultraline and 26% (11/42) in the Urolase group. The mean duration to catheter removal was 21 days (range 2-72) in Group I and 16 days (range 3-58 days) in Group II; with laser type, in Group I the mean durations were 24 days (Ultraline), 21 days (Urolase) and 19 days (TULIP). In Group II, the mean duration of catheterization was 17 days for the Ultraline and 16 days for the Urolase group. For Group I, in the group of patients with a positive urine culture, the catheter was removed after a mean of 24 days, while in the remaining patients the catheter was removed after 19 days; the results were similar in Group II (Table 1).

To investigate the influence of antibiotics, laser type and duration of catheterization on the probability of developing a UTI a logistic regression was performed. According to the likelihood-ratio test, the three regression variables combined were significant (P=0,01). Using the Wald test for each variable, there was no significant relation with laser type (P=0,29), but the

Table 2. *Post-operative complaints and the presence of a urinary tract infection in patients with (Group II) and with no (Group I) peri-operative antibiotics.*

	Urinary tract infection		
Group I	Yes	No	Total
number of patients	21	22	43
Complaints number (%)			
Frequency	15 (71)	12 (55)	27 (64)
Dysuria	16 (76)	12 (55)	28 (65)
Haematuria	16 (76)	12 (55)	28 (65)
Pain	7 (33)	5 (23)	12 (28)
Group II	Yes	No	Total
number of patients	22	51	73
Complaints number (%)			
Frequency	12 (55)	23 (45)	35 (48)
Dysuria	10 (46)	22 (43)	32 (44)
Haematuria	16 (73)	36 (71)	52 (71)
Pain	8 (36)	11 (22)	19 (26)

probability of developing a UTI is significantly higher (P=0,03) with a longer duration of catheterisation and although not significant (P=0,07) there tended to be a lower probability of developing a UTI with the use of antibiotics. Patients with a UTI had complaints for a mean of 45 days (range 6-149) and similarly, for patients with no UTI, the mean was 45 days (range 0-95) (Table 2). There was no clear relationship between the duration of the complaints, the type of complaints and the presence of UTIs. Table 3 shows the results of urine culture and the organisms cultured. Five patients (12%) in Group I developed epididymitis compared with seven patients (10%) in Group II.

Discussion

Transurethral resection of the prostate is the most common operation for bladder outlet obstruction and is one of the most frequently performed operations in men 65 years or older.[15] Amongst other new, less invasive treatments for BPE, transurethral laser treatment of the prostate has become available recently. The first report on the use of lasers to treat BPE were

Table 3. *Results of urine cultures*

Bacteria	Group I	Group II
Escherichia coli	4	3
Klebsiella pneumoniae	4	0
Staphylococcus aureus	4	2
Enterococcus faecalis	3	5
Acinetobacter baumannii	2	1
Proteus mirabilis	2	0
Citrobacter freundii	1	1
Enterobacter spp	1	0
Klebsiella oxytoca	1	1
Pseudomonas spp	1	3
Coag. neg. Staphylococcus	0	1
Staphylococcus epidermidis	1	5

presented by Costello et al.[16] In two recent papers reporting laser ablation of the prostate with different techniques [11,17], it was concluded that the outcome of treatment was excellent and that the morbidity after laser treatment was minor. However, the majority of patients had voiding complaints, possibly due to UTIs. On the other hand, a difference in the severity of complaints was noted when different techniques were used. It was thought that these differences may not be related to the presence of an infection.

No standard exists in the urologic community regarding the use of prophylactic antibiotics for TURP. The reported incidence of UTI in patients undergoing TURP ranges from 2.3[18] to 42%.[19] In several studies [5,20,21] prophylactic antibiotics were recommended and Childs stated that TURP should be classified as a contaminated procedure, with a 20% risk of infection, and also recommended prophylaxis.[22] To define the prevalence of prostatic bacterial infection, Gorelick et al. conducted a study in which tissue from patients undergoing prostatectomy was submitted for quantitative bacterial tissue culture.[23] These data showed a significant prevalence (21%) of prostatic infection in patients undergoing prostatic surgery.

In patients with a sterile pre-operative urine culture, no peri-operative antibiotics are administered for TURP in our department. When transurethral laser therapy became available, it was also decided that peri-operative antibiotics would not be used in these patients. However, during follow-up many patients had irritative complaints for several days to weeks after treatment and the incidence of UTIs seemed high.

In the present study, evaluation of the patients treated without peri-operative antibiotics showed that 48% of them developed a UTI. Indeed, compared to the incidence seen after TURP (mean 10-20%), this percentage is high. Three factors were evaluated to explain this high incidence; the presence of necrotic tissue after the procedure, the presence of an indwelling catheter and prolonged catheterization. Moreover, relationships between the complaints and the presence of a UTI were examined

The incidence of UTI was highest in the Ultraline group, followed by the Urolase and the TULIP group. However, adjusted for the use of prophylactic antibiotics and the duration of catheterization, there were no significant differences between those treated with the Ultraline and the Urolase fibers. The discrepancy in the incidence of UTIs for the three procedures was not related to the type of laser fiber but to the duration of catheterization. Al three fibers create extensive necrotic tissue, caused by coagulation. Thus the prostate turns into an ideal culture medium for bacteria, which may already be present in the prostate, as demonstrated by Gorelick et al.[23]

The presence of an indwelling catheter may support the incidence of UTIs. In those patients treated without prophylactic antibiotics, the mean time to catheter removal was 21 days. In cases of infection, the catheter was removed at a mean of 24 days while in the remaining patients the catheter was removed a mean of 5 days earlier. Patients with a prolonged indwelling catheters are susceptible to infection with mixed cultures of organisms.[4,24] In the 73 patients receiving prophylactic antibiotics a similar trend occurred; the mean duration of catheterization was 16 days, but was 21 days in infected and 15 days in the uninfected patients.

From the logistic regression analysis, it is concluded that this higher incidence of UTIs may be explained partly by a longer duration of catheterization. Recently Costa presented results of a randomised study to evaluate whether antibacterial prophylaxis is useful in laser ablation of the prostate.[25] In agreement with the present study, 50% of the patients in a group receiving no prophylaxis developed bacteriuria. In patients receiving a single-dose regimen of a difluoroquinolone, bacteriuria developed in only 10%, whereas 5% of those receiving a multi-dose regimen developed bacteriuria during follow up. In contrast to the present study, the median duration of catheterization was only 2-3 days; this may explain the difference in the results. On the other hand, infections may impair wound healing in the prostatic fossa and thus results in a need for prolonged catheterization. Although peri-operative antibiotics decreased the incidence of UTIs after treatment, the incidence of UTIs remained at 30%.

After laser treatment, significant epididymitis occurred in patients in both Group I and II. However, the incidence of epididymitis after TURP should not be underestimated. Epididymitis has been recognised as a complication of prostatic surgery for many years. Most urologists believe that the route of infection is through the lumen of the vas, and the incidence of epididymitis was estimated at 5 to 10%.[26] Possibly, urethral catheterization has only an indirect effect on the incidence of epididymitis, by potentiating urinary infection. Because of the morbidity caused by epididymitis, any means which decreases the incidence of epididymitis should be employed.

In the present study there was no evident relation between the presence or duration of complaints after laser treatment and the incidence of UTIs (Table 2). Therefore, one cannot rely on the complaints presented by these patients to determine whether a UTI is present and causing the complaints. However, the duration of complaints and the type of procedure performed were associated. In an earlier phase, it was noted that voiding complaints and perineal discomfort were more pronounced in the TULIP group than in the Urolase group[11] and that this difference may be explained by the different procedure performed. During the insertion of the TULIP device, more tissue trauma may be caused than with other techniques. Moreover, the TULIP device requires a 48-F balloon to be filled with 0.1-0.2 Mpa of pressure, which may cause a commisurotomy and stretching of the capsule of the prostate. Finally, patients treated with the Ultraline procedure may have more complaints than those treated with the Urolase because a larger area of the prostate surface is treated, sometimes very close to the bladder neck. Compared to the TULIP group, the patients treated with the Ultraline fiber had fewer complaints.

The high incidence of urinary tract infections after laser prostatectomy may have many causes. There was a poor relationship between complaints and the presence of UTIs. There is a paucity of reliable indicators to identify pre-operatively patients that will develop complaints post-operatively, or will have an UTI. The major cause seems to be prolonged catheterization, but currently it is impossible to predict which patients will develop an infection. Peri-operative antibiotics tended to reduce the post-laser UTIs, though there was no relation with the type of procedure performed. However, because few patients were treated within each group, firm conclusions cannot be made. Because of the high rate of infection found in the present study and the decrease in infections in the subsequent group of patients with peri-operative antibiotics, we have decided to proceed with laser therapy under prophylactic antibiotics (co-trimoxazole 960 mg twice daily for 5 days). When considering the routine use of antibiotics the potential disadvantages must be considered, including added costs, selection of resistant organisms and allergic reactions. If antibiotics are administered, for how long should they be continued and which antibiotic drug should be chosen? These questions need to be answered in a randomised (placebo) controlled study. Furthermore, the laser therapy of the prostate should be modified so that the need for (prolonged) catheterization is reduced.

References

1 Grabe M Antimicrobial agents in transurethral prostatic resection J Urol **138** 245, 1987

2 Morris MJ, Golovsky D, Guinness MDG, Mahner PO The value of prophylactic antibiotics in transurethral prostatic resection a controlled trial, with observations on the origin of postoperative infection Br J Urol **48** 479, 1976

3 Hargreave TB, Hindmarsh JR, Elton R Short term prophylaxis with cefotaxime for prostatic surgery Br Med J **284** 1008, 1982

4 Dorflinger T, Madsen PO Antibiotic prophylaxis in transurethral surgery Urology **24** 643, 1984

5 Hargreave TB, Botto H, Rikken GH, Hindmarsh JR, McDermott TE, Mjolnerod OK, Petays P, Schalkhauser K, Stellos A European collaborative study of antibiotic prophylaxis for transurethral resection of the prostate Eur Urol **23** 437, 1993

6 Gibbons RP, Stark RA, Correa RJ, Cummings KB, Mason JT The prophylactic use - or misuse - of antibiotics in transurethral prostatectomy J Urol **119** 381, 1978

7 Holl WH and Rous SN Is antibiotic prophylaxis worthwile in patients with TURP?

Urology **19** 43, 1982

8 Haverkorn MJ Prophylactic trimethoprim for prostatectomy Urology **24** 414, 1984

9 Hofer DR, Schaeffer AJ Use of antimicrobials for patients undergoing prostatectomy Urol Clin North Am **17** 595, 1990

10 Chodak GW, Plaut ME Systemic antibiotics for prophylaxis in urologic surgery a critical review J Urol **121** 695, 1979

11 de la Rosette JJMCH, Froeling FMJA, Alivizatos G, Debruyne FMJ Laser ablation of the prostate experience with an ultrasound guided technique and a procedure under direct vision Eur Urol **25** 19, 1994

12 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier HE, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy national human cooperative study results J Urol **150** 1607, 1993

13 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual laser ablation of the prostate clinical experience in 108 patients J Urol **150** 1612, 1993

14 Anson KM, Watson G Lasers in the treatment of benign prostatic hyperplasia in Contemporary BPH management, edited by Paolo Puppo, page 91-101, 1993

15 Holtgrewe HL, Mebust WK, Dowd JB, Cockett ATK, Peters PC, Proctor C Transurethral prostatectomy practice aspects of the dominant operation in American urology J Urol **141** 248, 1989

16 Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J Laser ablation of the prostate in patients with benign prostatic hypertrophy Br J Urol **69** 603, 1992

17 de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the ultraline and urolase laser fiber is there any difference? World J Urol **13** 98, 1995

18 Mebust WK, Holtgrewe HL, Cockett ATK, Peters PC and Writing Committee Transurethral prostatectomy immediate and postoperative complications A cooperative study of 13 participating institutions evaluating 3,885 patients J Urol **141** 243, 1989

19 Nielsen OS, Maigaard S, Frimodt-Moller N, Madsen PO Prophylactic antibiotics in transurethral prostatectomy J Urol **126** 60, 1981

20 Madsen PO, Larsen EH and Dorflinger T The role of antibacterial prophylaxis in urologic surgery Urology suppl **26** 38, 1985

21 Slavis SA, Miller JB, Golji H, Dunshee CJ Comparison of single dose antibiotic prophylaxis in uncomplicated transurethral resection of the prostate J Urol **147** 1303, 1992

22 Childs SJ Genitourinary surgical prophylaxis Infect Surg **2** 701, 1983

23 Gorelick JI, Senterfit LB, Vaughan Jr ED Quantitative bacterial tissue cultures from 209 prostatectomy specimens findings and implications J Urol **139** 57, 1988

24 Desai K, Abrams P, White LO A double-blind comparative trial of short-term orally administered enoxacin in the prevention of urinary infection after elective transurethral prostatectomy a clinical and pharmacokinetic study J Urol **139** 1232, 1988

25 Costa FJ Lomefloxacin prophylaxis in visual laser ablation of the prostate Urology **44** 933, 1994

26 Thomas WJC Epididymitis in relationship to prostatecomy Proc R Soc Med **60** 874, 1967

Quality of life assessment in patients following laser prostatectomy.

Accepted for publication in Br J Urol

Summary

Purpose: The importance of the assessment of quality of life was studied in patients following laser prostatectomy.

Material and Methods: Patients undergoing a laser prostatectomy were evaluated with the international prostatic symptom score (IPSS) questionnaire, uroflowmetry, post-void residual volume measurements and quality of life and sexual function questionnaires.

Results: Data for 103 patients were evaluated. Overall, significant improvement in mean IPSS, maximum flow, post-void residual and quality of life score was noted. There seemed to be no subjective change in sexual function. There was a good relation between the IPSS and the quality of life score. However, there was no correlation between the quality of life score and the maximum flow, and only a low correlation between the IPSS and the maximum flow.

Conclusion Laser prostatectomy significantly changes the quality of life. This may be more important for the patient than the improvement of voiding parameters alone. In the future (changes in) quality of life will probably contribute significantly in selecting patients with voiding complaints for treatment.

Introduction

Benign prostatic hyperplasia (BPH) is a common condition among men, with an estimated prevalence as high as 85 %.[1] BPH can cause Bladder Outlet Obstruction (BOO) with a large scale of symptoms varying from only mild voiding or filling complaints to recurrent urinary tract infections, acute retention or even renal failure. The majority of patients will visit their physician with mild to moderate complaints of urinary difficulties, so called lower urinary tract symptoms (LUTS). The influence of these LUTS on patients' daily activities and consequently on their quality of life will make patients demand some treatment. Since men do not always perceive their LUTS as problematic, the prevalence of symptoms in the community is higher than the number of men who seek medical or surgical attention.[2,3] Thus, besides the presence of symptoms, bothersomeness of these symptoms seems to play an important role in diagnosis and treatment of patients with LUTS. Several studies noticed the importance of a bother score of several symptoms. Also a correlation between these bother scores, symptom scores, and quality of life was established.[4,5]

Since decades the only treatment options for men, seeking help for LUTS as a result of BPH have been transurethral electroresection of the prostate (TURP) and open prostatectomy. During the last ten years several alternative treatments were introduced. These new treatment options were evaluated for their efficacy using symptom scores and objective measurements including u-roflowmetry, post void urinary residual and sometimes even urodynamic investigations with pressure flow studies. The number of publications reporting on the effect of a particular treatment on quality of life is limited. One of these alternative therapies is the use of laser energy in the treatment of BPH. This treatment option has been evaluated extensively and results with respect to improvement in symptom scores and uroflowmetry data, comparable with TURP, are documented in several publications.[6-8] However, little is known about the effect of laser treatment of the prostate on quality of life. In the current study patients were evaluated pre- and post-laser treatment with quality of life and sexual function questionnaires in addition to symptom-scores and the objective measurements as uroflowmetry and post void urinary residual.

Material and Methods

From December 1993 through June 1995 103 patients with LUTS and BPH underwent a laser prostatectomy. Two different side firing laser devices were used: the Urolase and the Ultraline fiber. All patients were evaluated at baseline with history, physical examination, including digital rectal examination (DRE), laboratory investigations, including PSA, urine culture and urinalysis. Symptoms were evaluated using IPSS, a Quality of life questionnaire and a sexual function questionnaire. The IPSS is the Dutch translation of the AUA-7 questionnaire and asks for symptoms in filling and voiding phases. The last question is about the effect of these voiding complaints on quality of life. The Quality of life questionnaire (app.1) consists of three parts: part A contains six questions about the general impact on the patient's life and quantifies some symptoms (range 6 - 24); part B contains five questions about the bothersomeness of specific symptoms (range 5 - 25); and part C contains only one question about general improvement or deterioration over the last month (range 1 - 5). The sexual function questionnaire (app.2) inquires about changes in sexual function after the laser treatment.

Furthermore, patients underwent transrectal ultrasonography (TRUS) of the prostate to document prostate abnormalities. In case of suspicion for prostate cancer ultrasound-guided biopsies were taken. The prostate volume was measured using the ellipsoid formula. To document changes in voiding parameters following laser prostatectomy uroflowmetry studies including post voiding residual volume measurements were performed. Patients were evaluated at baseline and at 3, 6 and 12 months postoperatively. The sexual function questionnaire was re-evaluated at 3 and 12 months.

Since earlier studies revealed no differences in clinical outcome using the Ultraline and the Urolase fiber the data were analysed as one group.[9]

Statistical analysis:

Differences for age, uroflowmetry data or residual urine volume, between patients who filled out all the questionnaires at follow up and patients who did not, were tested for statistical significance using the Wilcoxon test at each time of assessment.

Correlations were tested for statistical significance using the Spearman rank correlation test.

Changes after laser prostatectomy was tested for statistical significance using a two-way ANOVA with appropriate Tukey's contrast test for each variable separate. The independent variables were patient and day of assessment. The dependent variables were uroflowmetry parameters and the sum scores of the different questionnaires, respectively.

Results

There were no significant differences in baseline parameters, including age, between patients who did fill out the questionnaires at all times and patients who did not. When we look at improvement of uroflowmetry data and the effect of this on filling out the questionnaires there are no significant differences between patients who filled out the IPSS at all times and patients who did not. For the Quality of life questionnaire, however, there is a significant difference for the maximum flow at 3 months after treatment. It seems that patients who filled out the Quality of life questionnaire at all times had a significant higher maximum flow than patients who did not fill out this questionnaire at all times. This difference disappears at 6 and 12 months after treatment.

Symptom questionnaire (IPSS)

Of the 103 patients treated, 101 patients filled out the questionnaire at baseline. At 3, 6 and 12 months postoperatively this number was 95, 99 and 89, respectively.

There is a significant decrease in symptom score from 21.3 (range 11 - 35, SD 5.6) at base line to 8.0 (range 0 - 23, SD 5.5) at 3 months , 6.2 (range 0 - 35, SD 5.5) at 6 months and 5.4 (range 0 - 20, SD 4.4) at 12 months after treatment.(Fig.1)

At 6 months postoperatively only 3 patients did not improve in symptom score, which accounts for 3.1 %.

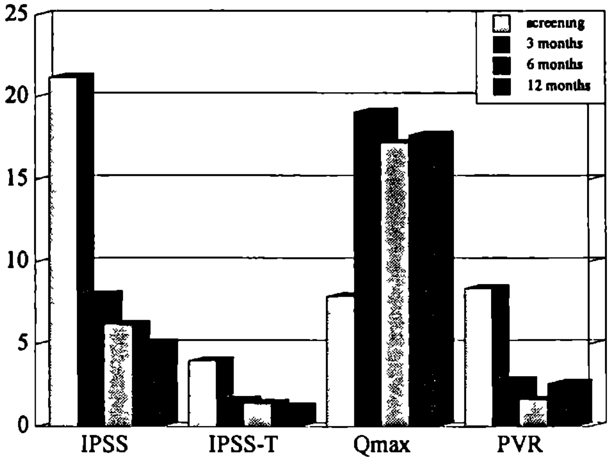


Fig. 1 *Mean IPSS, quality of life score of the IPSS (IPSS-T), maximum flow (Qmax; ml/s) and post-void residual volume (PVR); x 10 ml) at screening and 3, 6 and 12 months follow-up.*

Quality of life question of the IPSS

This question was filled out by 67 of the 103 patients at baseline. At 3, 6 and 12 months after treatment 56, 61 and 52 patients (who also filled out this question at baseline), respectively filled out this question. Like changes found in IPSS score, this question showed a significant drop in the score from 4 (range 1 - 6, SD 0.95) at baseline to 1.7 (range 0 - 6, SD 1.5) at 3 months, to 1.3 (range 0 - 4, SD 1.2) at 6 months and to 1.1 (range 0 - 3, SD 0.9) at 12 months after treatment.(Fig.1)

At 6 months postoperatively only 9 patients of the 61 did not improve in score, which accounts for 14.8 %.

Quality of life questionnaire

This questionnaire was filled out by 86 of the 103 patients at baseline. At 3, 6 and 12 months after treatment, 82, 83 and 74 patients (who also filled out this questionnaire at baseline), respectively filled out the questionnaire. When taking the sum score of this questionnaire there is a significant decrease from 25.2 (range 11 - 40, SD 6.3) at baseline to 18.2 (range 11 - 37, SD 6.5) at 3 months, to 15.1 (range 11 - 37, SD 5.0) at 6 months and to 13.8 (range 11 - 26, SD 3.5) at 12 months after treatment. If we look at the separate parts (A,B) of this questionnaire there is a significant decrease from 12.3 (range 6 - 21, SD 3.2) and 12.9 (range 5 - 21, SD 3.9) at baseline, to 9.9 (range 6 - 21, SD 3.5) and 8.3 (range 5 - 22, SD 3.6) at 3 months, to 7.9 (range 6 - 16, SD 2.5) and 7.2 (range 5 - 21, SD 2.9) at 6 months and to 7.2 (range 6 - 14, SD 1.8) and 6.6 (range 5 - 14, SD 2.1) at 12 months postoperatively. The score on part C of the questionnaire fluctuates from 3.4 (range 2 - 5, SD 0.7), to 1.5 (range 1 - 5, SD 0.9) at 3 months, to 1.9 (range 1 - 5, SD 1.1) at 6 months and to 2.5 (range 1 - 4, SD 0.9) at 12 months after treatment.(Fig. 2)

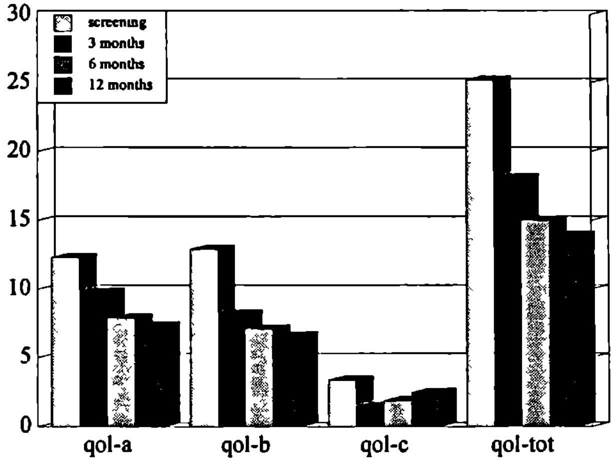


Fig. 2 *Mean score of the different parts and the sumscore of the quality of life questionnaire at screening and at 3, 6 and 12 months follow-up*

At 6 months postoperatively only 6 patients of the 83 did not improve in the sum score of this quality of life questionnaire, which accounts for 7.2 %.

Sexual function questionnaires.

Overall there was no significant change in how the patients experienced their sexual function three months and one year after treatment in comparison with the measurement at baseline. Of the 35 patients who said there was a change 3 months after laser prostatectomy, 21 patients (60%) said that there was an improvement and 14 patients (40%) stated that there was a deterioration in sexual functioning. Twelve months after laser prostatectomy there were 17 patients out of a total of 30 who stated that there was an improvement and 13 patients stated that there was a deterioration in sexual functioning.

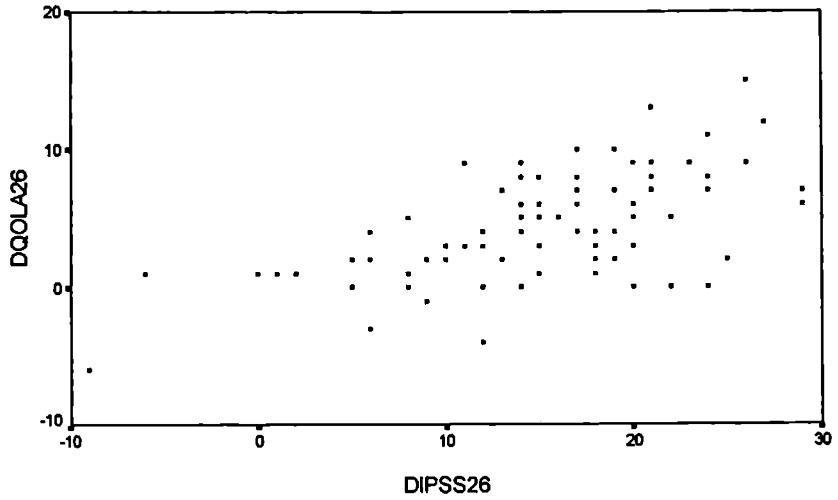
Uroflowmetry data

In 102 of the 103 patients a uroflowmetry with ultrasound guided measurement of the residual urine volume was performed at baseline. At 3 months after treatment 100 patients performed a uroflowmetry and in 99 patients the residual urine volume was measured. At 6 and 12 months postoperatively 97 and 91, respectively had uroflowmetry, and 92 and 86 patients, respectively had a residual urine volume measurement.

There is a significant improvement in maximum flow from 7.9 ml/s (range 2 - 15, SD 3.0) at baseline, to 19.1 ml/s (range 5 - 45, SD 6.9) at 3 months, to 17.2 ml/s (range 3 - 37, SD 6.5) at 6 months and to 17.7 ml/s (range5 - 40, SD 7.5) at 12 months after treatment. The same improvement was seen for the residual urine volume, with a decrease from 84 ml (range 0 - 385, SD 80.9) to 27.6 ml (range 0 - 200, SD 36.6) at 3 months, to 16.4 ml (range 0 - 200, SD 31.0) at 6 months and to 25.6 ml (range 0 - 165, SD 37.6) at 12 months postoperatively . There was no statistically significant difference between the data at 3, 6 and 12 months after treatment for both the maximum flow and the residual urine volume. (Fig.1)

At 6 months postoperatively only 7 patients of the 97 did not improve in maximum flow, which accounts for 7.2 %.

3a



3b

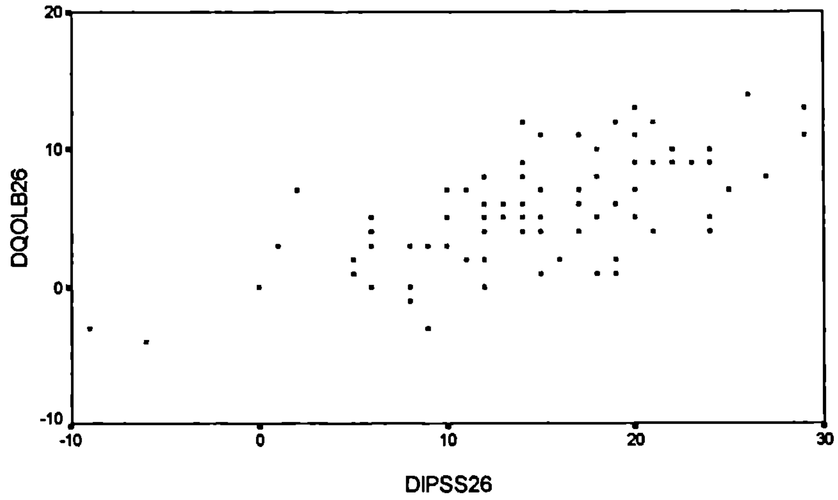
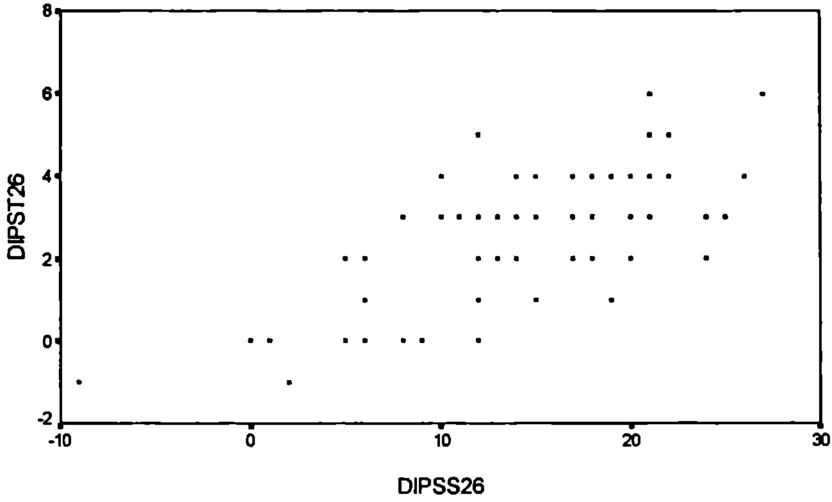


Fig. 3 *Relation between improvement in IPSS (DIPSS26) and* ***a)*** *quality of life score (part A)(DQOLA26); and* ***b)*** *quality of life score (part B)(DQOLB26) at 6 months*

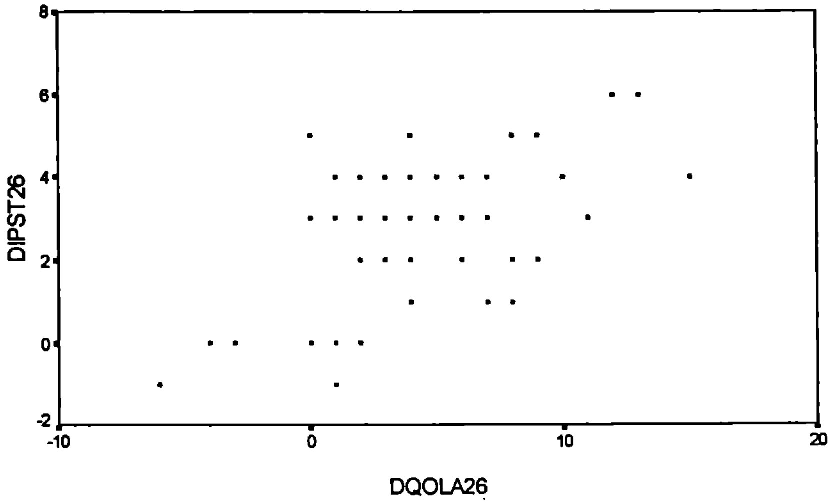
With the Spearman rank correlation test there is a significant correlation between the sum score of the IPSS and the separate scores of part A and B of the quality of life questionnaire of r=0.50 and r=0.56, respectively at baseline; r=0.64 and r=0.62, respectively at 3 months; r=0.50 and r=0.63, respectively at 6 months; and r=0.59 and r=0.61, respectively at 12 months after laser treatment. (Fig 3) The IPSS quality of life question also correlated significantly with the sumscore of the IPSS, and with the scores of part A and B of the Quality of life questionnaire with respectively r=0.66, r=0.51 and r= 0.56 at 6 months (Fig 4). There is a significant correlation at all evaluation points.

Besides a weak correlation of r=0.39 between the IPSS and the maximum flow rate at 6 months postoperatively no relation is found between the IPSS and the quality of life scores on one hand and the maximum flow rate on the other hand at baseline and follow up. Also the changes in IPSS sum score and the total Quality of life sum score after laser treatment do not show any relation with the change in uroflowmetry parameters postoperatively. (Fig 5)

4a



4b



4c

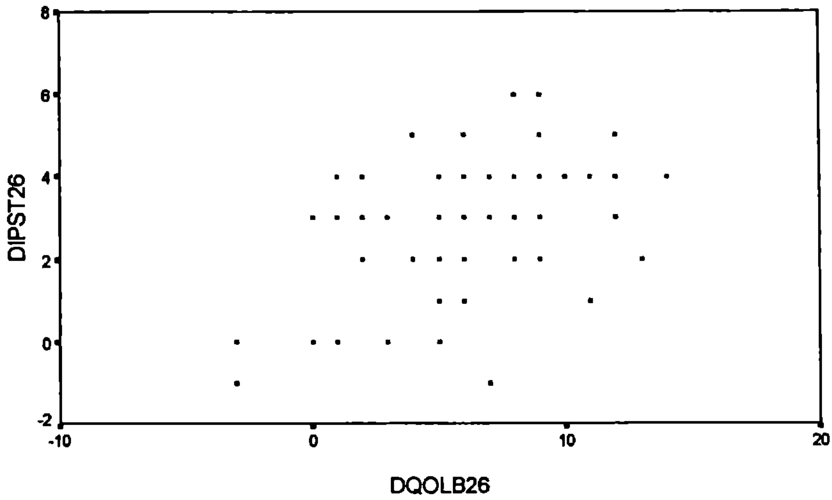
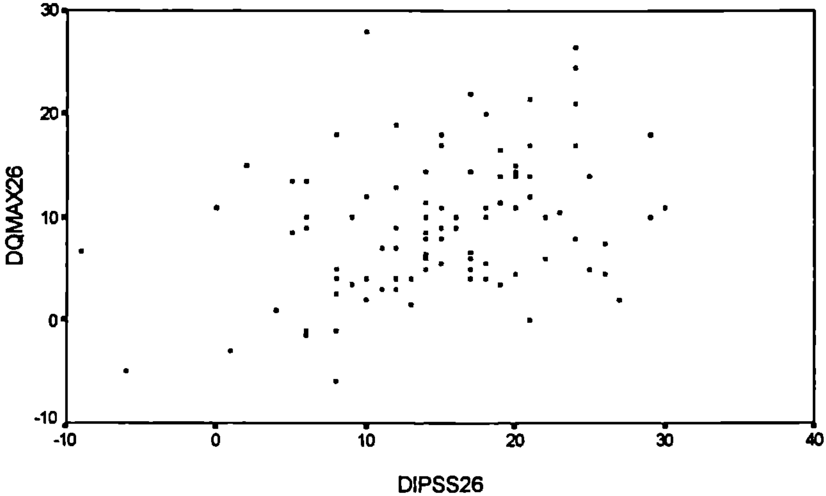


Fig. 4 *Relation between improvement in the single quality of life question of the IPSS (DIPST26) and* ***a)*** *the IPSS (DIPSS26);* ***b)*** *quality of life score (part A) (DQOLA26); and* ***c)*** *quality of life score (part B) (DQOLB26) at 6 months*

5a



5b

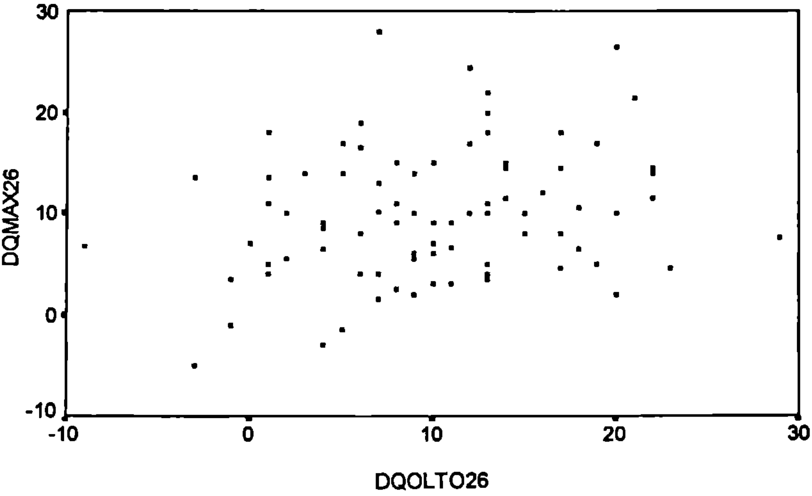


Fig. 5 ***a)*** *Relation between improvement in IPSS (DIPSS26) and maximum flow (Qmax) (DQMAX26) at 6 months; and* ***b)*** *relation between improvement in the sumscore of the quality of life questionnaire (DQOLTO26) and maximum flow (Qmax) (DQMAX26) at 6 months*

Discussion

The degree to which the patient is bothered by urinary difficulties, rather than symptoms per se, or the degree of the decrease in flow may be the most important influence on the decision of a patient to seek medical attention for the problem. Whether treatment is advantageous when there are significant objective findings of obstruction but little impairment in the quality of life or vice versa is not clear. Several reports already stressed the importance of bothersomeness of LUTS and the effect of that on quality of life.[4,10,11] Fowler et al found that men who are bothered by symptomatic BPH are most likely to experience a dramatic improvement from transurethral resection of the prostate.[12] Therefore studies on effect of treatment in patients with LUTS and BPH, have to use symptom questionnaires and especially bothersome and quality of life questionnaires in addition to objective parameters such as uroflowmetry and pressure-flow studies.

In a study of Sagnier et al[10] the IPSS sum score was highly correlated with the AUA-bother-score (r=0.85) and also the separate quality of life question of the IPSS correlated well with the AUA- botherscore (r=0.60). A good correlation between the IPSS sumscore and the separate quality of life question of the IPSS was also reported (r=0.74).[11] In the present study we found also a significant correlation between the sum score of the IPSS and the separate scores of part A and B of the quality of life questionnaire. Furthermore, according to the literature, there seems to be only a low correlation between symptom scores and uroflowmetry data in a community-based sample of men[13] as well as in men with the clinical diagnosis of BPH.[14] The current study observed only a weak correlation between the sum score of the IPSS and maximum flow rate only at 6 months after laser treatment. No relation was found at the other evaluation points. There was also no relation found between the sum score of the quality of life questionnaire and maximum flow rate at baseline and follow up. Despite this observation we do see a significant improvement in all these parameters after the laser treatment of the prostate (Fig1 and 2).

There are only a few reports of changes in quality of life after treatment for LUTS. A prospective study of BPH treatment choices in 546 patients suggested that men with the same level of symptoms may not be equally bothered, and that patients perception of quality of life must be taken into account when one is considering treatment options.[15] In a separate report of an uncontrolled study at least 60% of consecutive surgical patients reported that the primary reason for prostate surgery was symptom reduction and improvement in quality of life.[16] Lukacs et al[17] reported improvement in quality of life after treatment with an alpha blocker, although this study was uncontrolled. Emberton et al[18] performed a study on the effect of prostatectomy on symptom severity and quality of life. It was concluded that changes in symptom severity were highly correlated with bothersomeness and disease specific quality of life. They stated furthermore that prostatectomy is effective in reducing symptoms in most men and that men who experienced a substantial reduction in symptoms were more likely to report a favourable outcome. To our knowledge the current study is the first which reports on quality of life after laser prostatectomy. The quality of life data have limitations, because quality of life questionnaires are not validated yet. The proceedings of the third international consultation on BPH therefore could not recommend a quality of life questionnaire at this moment.[19] Naturally we realise that a validated international bothersome and quality of life questionnaire has to be developed. Since there appeared to be a good relation between the single quality of life question of the IPSS and the Quality of life questionnaire used in this study, we wondered whether only the single quality of life question of the IPSS questionnaire would be sufficient to document changes in quality of life adequately in these patients. Although there is a significant correlation between this single quality of life question of the IPSS and the sum score of the IPSS and the score of part A and B of the quality of life questionnaire, the correlation is to low to state that this single question can replace the a more differentiated questionnaire. Moreover several studies already showed that there are geographical or cultural differences in the prevalence of symptoms and in symptom severity. Guess et all[20] showed a difference in prevalence of symptoms between Scottish men and men from Minnesota. Scottish men reported less symptoms but a slightly greater amount of bother was associated with a given level of symptoms. Also the ICS-BPH study concluded that in various countries specific LUTS may be presented in a distinct way.[21] The perception of specific LUTS appeared to be associated with the country of origin. As a result probably each country with its own cultural background and specific health care delivery system has to validate the efficacy and quality of life aspects of new treatment modalities for LUTS.

In conclusion, this study showed only a weak correlation between symptom score and uroflowmetry parameters, no correlation between Quality of life and uroflowmetry data, and a strong correlation between quality of life and symptom scores. Laser treatment of the prostate does not only change objective parameters but also changes the quality of life. The latter may be more important for the patient than the increase in maximum flow rate. In the future quality of life questionnaires and bothersomeness of particular symptoms will probably be more important in selecting patients for treatment of LUTS as a result of BPH than other parameters.

References

1. Lytton B, Emery JM, Harvard B. The incidence of benign prostatic obstruction. J Urol **99**: 639, 1988
2. Garraway WM, Collins GN. Lee RJ. High prevalence of benign prostatic hyperthrophy in the community. The Lancet **338**: 469, 1991
3. Drummond MF, McGuire AJ, Black NA, Petticrew M, Mc Pherson CK. Economic burden of treated benign prostatic hyperplasia in the United Kingdom. Br J Urol **71**: 290, 1993
4. Girman CJ, Epstein RS, Jacobsen SJ, Guess HA, Panser LA, Oesterling JE, Lieber MM. Natural history of prostatism: Impact of urinary symptoms on quality of life

in 2115 randomly selected community men Urol **44** 825, 1994

5 The department or veterans affairs cooperative study of transurethral resection for benign prostatic hyperplasia A comparison of quality of life with patients reported symptoms and objective findings in men with benign prostatic hyperplasia J Urol **150** 1696, 1993

6 te Slaa E, Mooibroek JJ, de Reijke ThM, Karthaus HFM, van Capelle J-W, Tjon Pian Gi N, de la Rosette JJMCH Laser treatment of the prostate using the Urolase fiber The Dutch experience J Urol **157** 420, 1996

7 Kabalin JN Laser prostatectomy performed with a right angled firing neodymium YAG laser fiber at 40 watts power setting J Urol **150** 95, 1993

8 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual laser ablation of the prostate clinical experience in 108 patients J Urol **150** 1612, 1993

9 de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the Ultraline and Urolase laser fibers Is there any difference? World J Urol **13** 98, 1995

10 Sagnier PP, MacFarlane G, Teillac P, Botto H, Richard F, Boyle P Impact of symptoms of prostatism on level of bother and quality of life of men in the French community J Urol **153** 669 1995

11 Bosch JLHR, Niemer AQHL, Kirkels WJ, Schroder FH Signs and symptoms of benign prostatic hyperplasia in men screened for prostatic carcinoma Benign prostatic hyperplasia Recent progress in clinical research and practice EORTC genitourinary group monograph 12 Page 97-107, Wiley-Liss, New York, 1994

12 Fowler FJ Jr Wennberg JL, Timothy RP Barry MJ, Mulley AG Jr, Hanley D Symptom status and quality of life following prostatectomy JAMA **259** 3018, 1988

13 Bosch JLHR, Hop WCJ, Kirkels WJ Schroder FH The International Prostate Symptom Score in a community-based sample of men between 55 and 74 years of age prevalence and correlation of symptoms with age, prostate volume, flow rate, and residual urine volume Br J Urol **75** 622, 1995

14 Barry MJ, Cockett ATK, Holtgrewe HL, McConnell JD, Sihelnik SA, Winfield HN Relationship of symptoms of prostatism to commonly used physiological and anatomical measures of the severity of benign prostatic hyperplasia J Urol **150** 351, 1993

15 Fowler FJ Jr, Barry MJ Quality of life assessment for evaluating benign prostatic hyperplasia treatments An example of using a condition-specific index Eur Urol (Suppl 1) **24** 24, 1993

16 Fowler FJ Patient reports on symptoms and quality of life following prostate surgery Eur Urol (Suppl 2) **20** 44, 1991

17 Lukacs B, McCarthy C, Grange JC, and the Qol BPH Study Group in General Practice Longterm quality of life in patients with benign prostatic hypertrophy preliminary results of a cohort survey of 7,093 patients treated with alpha-1-adrenergic blocker, alfuzosin Eur Urol (Suppl 1) **24** 34, 1993

18 Emberton M, Neal DE, Black N, Fordham M, Harrison M, McBrien MP, Williams RE, McPerson K, Devlin HB The effect of prostatectomy on symptom severity and quality of life Br J Urol **77** 233, 1996

19 Mebust WK, Donovan J, Bosch R, Okada K, O'Leary M, Batista J, Boyle P, Villers A, Ackermann R, Hoke G, Lukacs B, Mortensen S Symptoms Evaluation, Quality of life and Sexuality In The third International Consultation on Benign Prostatic Hyperplasia (BPH) Edited by ATK Cockett, S Khoury, Y Aso, C Chatelain, L Denis, K Griffith, G Murphy Vol 3, pp 257-274, 1995

20 Guess HA, Chute CG, Garraway WM, Girman CJ, Panser LA, Jacobsen SJ, McKelvie GB, Oesterling JF, Lieber MM Similar levels of urological symptoms have similar impact on Scottish and American men - Although Scots report less symptoms J Urol **150** 1701, 1993

21 Witjes WPJ, de la Rosette JJMCH, Donovan JL, Kay HE, Peters TJ, Abrams PH, and the ICS-"BPH" study group The ICS-"BPH" Study International diferences in lower urinary tract symptoms and related bother in the eldery male patient (submitted)

Appendix 1

Patients Quality of Life Questionnaire
part A

1. How many problems do you have with your voiding pattern?
    1. none
    2. little
    3. moderate
    4. much

2. Do your problems with voiding interfere with your normal daily activities?
    1. no
    2. slightly
    3. moderate
    4. much

3. Do your problems with voiding interfere with your normal social life?
    1. no
    2. sligthly
    3. moderate
    4. much

4. Did you ever had to void without controlling the time of voiding?
    1. never
    2. yes, 1 or 2 time(s) per month
    3. yes, 1 or 2 time(s) per week
    4. yes, every day

5. Did you ever wet your clothes? (because of the urge to void)
    1. never
    2. yes, 1 or 2 time(s) per month
    3. yes, 1 or 2 time(s) per week
    4. yes, every day

6. Did you ever wet your bed?
    1. never
    2. yes, 1 or 2 time(s) per month
    3. yes, 1 or 2 time(s) per week
    4. yes, every day

part B

For the next questions you must choose one of the answers which will show how troublesome the problem in that question was over the last month.

1. terminal dribbling or wetting your clothes
    1. no problem
    2. very small problem
    3. small problem
    4. a problem
    5. large problem

2. unpleasant sensation of a full bladder
    1. no problem
    2. very small problem
    3. small problem
    4. a problem
    5. large problem

3. Fear that you cannot void when you have a full bladder
    1. no problem
    2. very small problem
    3. small problem
    4. a problem
    5. large problem

4. Concern about the long distance you have to cover before you can void.
    1. no problem
    2. very small problem
    3. small problem
    4. a problem
    5. large problem

5. Being embarrassed about having to go to the toilet very frequently.
    1. no problem
    2. very small problem
    3. small problem
    4. a problem
    5. large problem

part C

Are your voiding complaints over the last 2 to 3 months

1. very deteriorated
2. slightly deteriorated
3. unchanged
4. slightly improved
5. very improved

Appendix 2

Sexual function questionnaire

1. Did the laser treatment changed your sexual life?
    1. no
    2. yes

2. If you answered yes, you find it
    1. satisfying
    2. rather satisfying
    3. rather unsatisfying
    4. unsatisfying

Chapter 6

Review of laser application in benign prostatic obstruction

Based on :

E. te Slaa, J.J.M.C.H. de la Rosette.
Lasers in the treatment of benign prostatic obstruction: Past, Present and Future. Eur Urol, 30: 1-10, 1996

Abstract

Lower urinary tract symptoms caused by benign prostatic obstruction (BPO) has been, and still is, treated by performing a transurethral or open prostatectomy. During the last decade many alternative treatments have been introduced and one of these new modalities uses laser energy in the ablation of prostatic tissue. When reviewing the literature on laser treatment of the prostate using side-firing laser devices, this procedure has proven to be safer and almost as effective as transurethral resection of the prostate (TURP). But although severe complications as TUR syndrome, incontinence and the need for blood transfusions have not occurred during laser prostatectomies, morbidity consisting of irritative voiding complaints and long catheterization duration have been reported by several authors. With the development of the contact laser probe and the interstitial laser technique some of these problems are (partly) solved, but also these new techniques still have considerable limitations which may disappear with future developments of newer laser probes and refining of existing laser techniques. Also, a better understanding and control in the laser-tissue interaction may help in reducing morbidity and inducing a more effective treatment.

Introduction

Lower urinary tract symptoms caused by male bladder outlet obstruction has presented a clinical problem throughout medical history. Already three centuries ago it was suggested that prostatic enlargement could result in mechanical obstruction of the bladder outlet tract. Consequently, relieve of bladder outlet obstruction can be attained by removal of obstructing prostatic tissue. Until a decade ago, the only generally accepted treatment modality to achieve disobstruction was prostatectomy. In spite of the proven safety and efficacy of this procedure, the morbidity caused by the operation has led to a universal search for acceptable alternatives. Many types of treatment have been introduced in the wave of new technologies; some have been the subject of initial enthusiasm but have subsequently fallen by the wayside (balloon dilatation, stents, hyperthermia).[1,2,3]

One of the new thermal therapies is the use of laser technology in the ablation of prostatic tissue. Laser has been used in the treatment of prostatic disease since about 15 years. Beisland and Sander were among the first when they in 1981 used laser irradiation of the prostate capsule after transurethral electro-resection of the prostate in the treatment of localised prostate cancer.[4] Later in 1985, Shanberg et al described the results of prostatotomy using Nd-YAG laser in patients with voiding symptoms secondary to benign prostatic hyperplasia.[5] The laser light was delivered through an end-firing bare fiber which was brought in contact. To test the safety of laser energy in the treatment of benign prostatic enlargement, Kandel et al performed animal studies using a bare fiber to deliver the energy via a perineal urethrostomy.[6] With the end-firing bare fibre it was difficult to aim the beam at the prostatic lobes. The development of a side-firing device solved this problem. Following the canine feasibility studies with a free beam side-firing system under cystoscopic control by Johnson et al[7] and with the transurethral ultrasound-guided laser-induced prostatectomy (TULIP) system in which transurethral ultrasound is used to guide the laser beam by Roth et al[8], the first laser prostatectomies performed in men were reported by Costello et al.[9] Since then the laser was introduced for the treatment of symptomatic benign prostatic obstruction (BPO), and numerous treatment devices have been developed and reported on, and this technology has achieved an important place in our urologic surgical armamentarium. This article reviews current laser applications in the treatment of (BPO) and possible future uses of lasers in this field.

Types of laser application

A variety of approaches have been put forward to perform a laser prostatectomy. Before discussing these approaches in more detail, it is essential to be aware about the parameters that may influence laser-tissue interaction. Laser light is a unique form of energy with characteristic and variable tissue effects. When the laser beam hits the tissue, it will be partly absorbed, reflected, transmitted and dispersed. Depending on several factors such as colour of the prostatic mucosa, blood perfusion and tissue texture of the prostate, more or less laser light will be absorbed. The aim of a laser prostatectomy can be defined as the relief of symptoms, caused by obstructive prostatic tissue, by the application of laser energy. Removal of abundant tissue is possibly the key mechanism. The tissue removal can be obtained in two different ways: (1) indirectly by heating the tissue to a maximum of 100°C, thus causing the coagulated tissue to slough after the procedure, or (2) instantaneously by vaporising the tissue while the temperatures rise over 300°C.

One of the first devices developed to apply laser energy to the prostate was the TULIP system. It combines a real-time ultrasound transducer and a Nd:YAG laser delivery system with a urethral probe. Several investigators have reported their experience with this device.[10-13] Although their results were very encouraging, currently it is not being used anymore. The majority of patients treated with TULIP will experience substantial improvements in subjective and/or objective parameters, however, the procedure appeared to be cumbersome and the morbidity considerable.[12,13] With the introduction of side-firing flexible fiber delivery systems, laser treatment of the prostate gained acceptance as an alternative treatment of BPO. The non-contact side-firing laser technology has made the procedure user-friendly and time-efficient for all urologists. These fibers mainly possess coagulation properties, and most experience is reported on the use of the Urolase side-firing fiber. Costello et al. where among the first to study the application of laser energy using side-firing techniques in the treatment of BPO. Overall laser treatment using the Urolase fiber results in an impressive improvement in uroflow and a significant decrease in symptoms.[14-18] The results where so encouraging that numerous side-firing fibers were introduced for the treatment of BPO.[15,19,20] As a result of this early experience, laser prostatectomy became popular with many urologists because it was considered to be associated with a morbidity lower than that resulting from transurethral resection of the prostate (TURP) while maintaining an excellent objective and subjective outcome. Although in the initial reports morbidity was considered to be relatively low, it still appeared to be considerable. There appeared to be a prolonged need for catheterization following side-firing laser treatment. During this period, often irritative voiding complaints for several weeks were found. The need for prolonged catheterization can be explained by the laser light effect itself. When a Nd:YAG laser beam is incident on prostatic tissue at power densities sufficient to coagulate the prostate, the gland shrinks to a minor extent due to the coagulation effect on protein and to the dissociation of the tissue. The prostate becomes rigid. This is followed by a period of cellular infiltration and swelling of the tissue. The patients will almost universally have a period of retention, lasting on average of 1-3 weeks.[15,21] Therefore, it was suggested that one should move away from purely coagulative techniques, which do not debulk the prostate to any measurable extent, toward a more vaporising-oriented approach.[22] This treatment modality causes tissue to convert into vapors of water and hydrocarbons, thus creating immediate cavitation. Several approaches have been developed to achieve this aim. Some companies provided fibers to be used in contact and/or a noncontact mode,[15,19,23] while one company developed a laser probe especially developed to be used in contact only.[24]

Narayan et al have presented their results, using the Ultraline fiber in contact and noncontact.[25] The main finding of their study was that transurethral evaporation of the prostate, in the short term, provides symptomatic relief and improvement in urine flow comparable to that with TURP. De la Rosette et al., however, could not confirm the early recovery of adequate spontaneous micturition and diminution of the symptoms.[15] It seems that in fact these side-firing fibers posses only minimal vaporising abilities. Obviously only pure contact laser prostatectomy is the practical way of achieving adequate vaporisation. Shanberg et al. were among the first to describe a method for laser prostatectomy wherein an end-fire Nd:YAG laser fiber was placed in direct contact with he prostatic tissue.[5] To achieve adequate ablation, Sapphire-tip probes have been developed as a more effective method for direct contact vaporisation of tissue. The contact of the delivery system with the tissue results in a higher power density than is usually achieved with a free-beam approach. In addition, the contact tip may be coated with an infrared absorber, or it may become slightly coated with carbon after contact with the tissue. This, therefore increases the absorption of laser light at the fibertip and, as a result of using the fiber in contact, induces very high temperatures at the prostatic surface. This promotes the tendency to vaporise tissue. Watson presented his results on patients treated with the SLT contact system, using the MTRL 10 probe.[24] This author concluded that the patient is disobstructed immediately, and that indwelling catheters can frequently be removed the next day. The incidence of urinary tract infection and dysuria is low. However, this system also has its disadvantages. Until now, the primary limitation has been that, even with some of the design changes and improvements, vaporisation of the prostate has been relatively slow and tedious, especially when a large amount of tissue is involved. Contact laser treatment of the prostate theoretically is appealing because the technique results in immediate tissue vaporisation: thus, therapeutic results do not depend upon secondary tissue destruction. In view of the limitations of the present contact probes, new developments are awaited to continue to increase efficacy of energy transmission. Currenlty it is recommended to treat only prostatic volumes of 40 cm^3 or less. Finally, Muschter and Hofstetter developed a device to be used for intraprostatic laser application.[26] In contrast to any heat treatment where energy from a source inside the urethra is delivered to the periurethral prostatic tissue, interstitial energy delivery would not affect the urethra. As a consequence, there would be no destruction of the urethra with sloughing of necrotic tissue, thus avoiding all related problems, such as irritation. The necrotic material was expected to be resorbed with time, leading to an atrophic, shrunken gland. Few authors have reported their

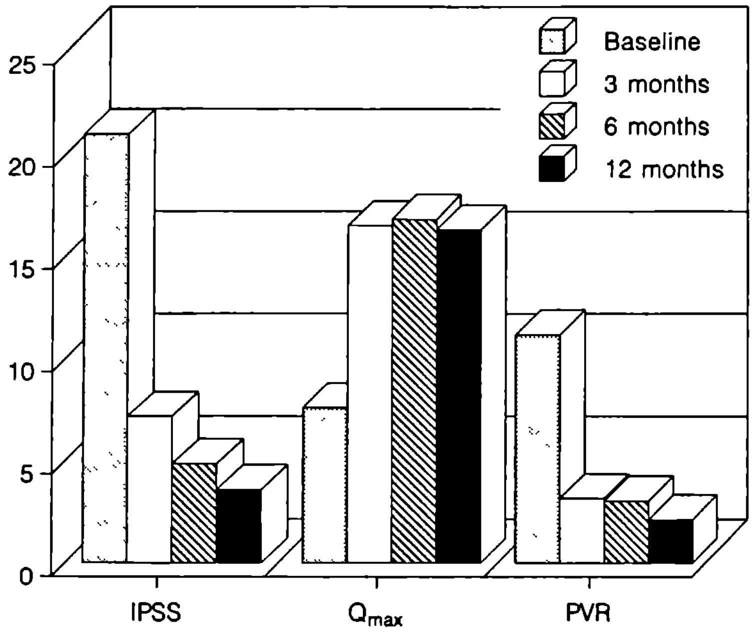


Fig 1. *IPSS symptom score, Qmax (ml/s), and PVR (10 x ml) at baseline and after 3, 6, and 12 months of follow-up. Data from te Slaa et al.*[45]

experiences with the interstitial laser coagulation using bare fibers or the technique described.[27,28] The results thus far are similar to those with side-fire laser coagulation of the prostate and there is a similar prolonged period of postoperative suprapubic catheter drainage. Because the potential advantage of this technique over free-beam laser coagulation is the preservation of the prostatic urethra, a reduction in postoperative voiding discomfort is found.[29]

Recent experience

Laser techniques have evolved through the experience of many investigators. Although several clinical studies were conducted on early techniques, well-designed clinical studies have lagged behind the progress in surgical methods. It is, therefore, difficult to determine which modifications in technique have improved clinical efficacy, morbidity, and safety. The results achieved thus far will be discussed in the following section. Because most devices eventually show similar improvements in objective and subjective parameters, we will not go into details concerning this aspect of laser prostatectomy. In Fig. 1 the results of a large number of patients treated by laser prostatectomy are presented.

Safety

The safety of any new device is of obvious importance. Safety should be guaranteed for the user as well as for the patient. The main concern of safety for the physician during the laser is guaranteed by standard laser safety precautions. A special room for laser treatment is prepared, while all people during the treatment wear safety glasses. Moreover, in case of any technical problem, the majority of modern laser energy sources are provided with an automatic emergency program, resulting in termination of the emission of laser energy.

The safety for the patient should be expressed in the incidence of complications caused by the laser treatment itself, either by the instruments used or the laser energy applied. In general, laser prostatecomy has minimised the majority of complications such as bleeding, TUR syndrome, and incontinence.[17,26] None of these problems has been seen in the multicenter trials of side-firing laser techniques. Less severe complications such as urethral stricture also seem to be less common. This will be discussed in more detail in the Morbidity section. The incidence of fistulas is only known from case reports.

As more experience has been gained, more aggressive lasing has been performed using higher powers, longer times and more applications without compromising safety.[30] It is fair to conclude that laser is safe in use. It is one of the reasons why the safety of laser devices in general makes them very appealing as an alternative to TURP.

TURP versus laser

The early clinical results of laser treatments are superior to all of the alternative treatments for BPO. Laser prostatectomy has rapidly become a widely used procedure, primarily because of its ease to use, the minimal bleeding and the impressive safety profile in comparison to TURP. However to be able to challenge the predominant TURP as an appropriate surgical option for treatment of BPO, laser therapy should provide results comparable to TURP.

To compare the efficacy of laser prostatectomy with TURP, this is only possible by performing randomised controlled trials. Several studies have been conducted, and the urolase fiber has undergone the most extensive clinical trials.[13,16,31-33] The level of improvement in the symptom scores was significantly greater for the TURP group than for the laser-treated group. The objective improvement is expressed in uroflowmetry results. The absolute improvement is less for the laser-treated group than for the TURP group; however, the difference between the increases in maximum urinary flow for the two treatment groups was not statistically significant. Although uroflowmetry results are associated with obstructive voiding, these parameters are not associated with the grade of obstruction, and, therefore, they cannot be used to determine objectively whether outlet obstruction is relieved.[34] To quantify the grade of bladder outlet obstruction, urodynamic investigation with pressure/flow analysis is considered the gold standard.[35] To judge the obstruction-relieving capabilities of laser treatment of the prostate, urodynamic studies need to be performed before and after treatment. Several studies indicate that laser is indeed capable to relieve BPO and that the urodynamic results are comparable to results obtained with TURP.[36,37] Moreover, no apparent difference in ability to relieve obstruction was shown for different fibers and techniques.[38] However, one has to keep in mind that the types of devices used in comparative studies between laser treatment and TURP are limited. As over ten different devices are available at present, one would expect that these would differ in terms of response and outcome. The question as to the type of applicator that should be used is fundamental. To our surprise, the results achieved with these fibers are more or less similar. One might think that the general effect of laser light on tissue would be most important, not the device or technique used. However, several authors showed that different devices and/or techniques used, really differ in their abilities to BPO efficacious.[18,39] Therefore, one may conclude that only those devices as studied in the aforementioned papers and using the outlined power setting can claim dis-obstructive capabilities.

Morbidity

Despite many surgical and technical improvements, the rate of total morbidity related to TURP has remained at approximately 20%.[40-42] Therefore, a variety of alternative minimally invasive treatment modalities are under investigation. The major complications such as incontinence, transfusion, and TUR syndrome have not occurred during laser prostatectomy (Table 1). The fluid shifts occurring during laser prostatectomy are minimal.[43] With the exception of bladder-neck contractures, the incidence of post operative urethral strictures appear to be almost nil after laser treatment. Presumably,

Table 1. *Morbidity and retreatment rates after TURP and different kinds of laser application. (n.m.= not mentioned; * all during 'learning curve' period)*

Morbidity	TURP[40-42]	Side-firing fiber[15-18,45]	Contact fiber[24]	Interstitial[26,27]
Tranfusion%	2.5-14	0-1.3	0	0
Tur-syndrome%	0.8-1.5	0	0	0
Catheterization,days	2-5	5-21	2-3	5-14
Irritative voiding complaints%	6-15	20-85	<10	13
Urinary tract infections%	2.3-14	30-50	<10	35
Bladder neck contractures%	2.8	0-5.8	n.m.	1.7
Urethral strictures%	0.6-6.3	0.4	n.m.	5.4*
Incontinence%	0.2-19.1	0	0	0
Erectile dysfunction%	0-40	0-13	n.m	0
Retrograde ejaculation%	55-90	20-47	35	7
Retreatment%	12-15 after 8 yrs	0-8.8 after 1 yr	n.m	<1 after 1 yr

this is due to the shorter procedure and to the use of a cystoscope that is considerably smaller than a conventional resectoscope. Bladder neck contractures seem to occur at similar rates.

The main drawback of laser prostatectomy is the incidence of posttreatment irritative voiding complaints and catheter-dependent retention. Depending on type of fiber and technique used, up to 50% of patients experience, during 2-6 weeks, marked difficulties in voiding.[15] This is presumably due to the thermal injury and delayed destruction that occur after treatment. Another reason may be irritation of the trigone following laser prostatectomy, resulting in hyperactivity of the bladder which may cause bladder cramps. This is endorsed by the finding that when using the interstitial lasing technique or the SLT contact system, only few patients suffered irritative symptoms.[24,26] Fortunately, these symptoms have always resolved and can be controlled by oral medications. Also the catheter-dependent retention may vary from 0 days to 8 weeks, depending on the devices and techniques used. In general, techniques achieving immediate formation of a cavity, obviously do not require prolonged catheterization. Moreover, a different time interval is suggested, depending on the type of catheter inserted. It is noticed that following transurethral catheter placement, this can be removed at an earlier stage that following suprapubic catheter placement.

Bleeding occurring at the time of surgery or after treatment is markedly reduced by the laser procedure. Transfusion, continuous bladder irrigation, and delayed clot retention have been shown to be involved to a much lesser extent after laser treatment than after TURP. Moreover, the procedure has also been successfully performed in patients taking coumarin without interrupting their anticoagulation.[44]

One should also address the changes in sexual function following laser treatment. In general, retrograde ejaculation occurs much less frequently in such cases than after TURP. In a recent study performed in the Netherlands, the retrograde ejaculation ratio appeared to be 47%.[45] Also impotence has been reported after laser treatment, but its incidence also appears to be significantly lower than after TURP. The proportion of diminished or absent erectile function in the aforementioned study was estimated to be 12.6%. These changes in sexual functions may be explained by a damage of the periprostatic nerves following laser treatment. However, it is suggested that also psychological factors may play an important role in this respect.

Retreatment

The objective success of treatment is usually defined by an improvement in objective and subjective parameters. The success of a treatment also depends on the necessity and the incidence of retreatment, and the interval between the initial treatment and the period of retreatment. The retreatment rate of TURP has been documented in several retrospective studies. One of the best known is the Manitoba Study performed by Roos et al.[46] The study revealed a rising percentage of patients undergoing a second prostatectomy (2.3-4.3%, 8.9-9.7%, and 12.0-15.5% after 1, 5, and 8 years, respectively). A population-based study by Chute et al. even showed that within a 30-day period after operation, 1.8% of the patients needed repeated prostatectomy.[47] The results achieved with laser treatment thus far are exciting and very promising. Short term follow-up shows a low retreatment percentage, ranging from 1.4% to 17.6% depending on the device used and the follow up period. The results of a multicentric Dutch study show that at 1 year follow-up, 4.7% (n=11) of patients had a TURP, a second laser treatment was performed in 1.7% (n=4), a bladder neck incision was required in 1.3%, while a internal urethrotomy had to be performed in 0.4% (n=1).[45] The largest experience is documented by Costello et al.[17] who had a continuing experience with the use of Nd:YAG laser fiber prostatectomy over a period of 4 years. The results showed a sustained reduction in symptoms and maintained improvement in uroflowmetry parameters with stabilisation of these parameters occurring within 12-36 months. Following laser ablation of the prostate in 198 patients, only 1% of patients needed treatment for a bladder-neck stenosis. A revision surgery was required in 8% (n=16) of patients, respectively at 6 weeks (n=5), 3 months (n=3), 6 months (n=4), and 12 months (n=4). These results demonstrate the low incidence of retreatment following laser prostatectomy.

Durability

Although the design of most devices differ substantially, there are nonetheless some physical similarities. Either coagulation necrosis, direct vaporisation, or a combination of the two can be obtained using each device with the appropriate dosimetry protocol. A factor associated with tissue destruction is the amount of energy delivered to the prostate that will eventually be absorbed by the prostate gland. This depends on a number of variables, such as reflection of laser light, changes in tissue characteristics during lasing, tissue cooling via increased prostatic blood flow, the colour of the prostatic mucosa, and loss of power output due to fibertip decrease during the laser procedure. Several studies have been performed to investigate the posttreatment decrease in the quality of the laser fibers.[48,49] Indeed a difference in durability was found between the different fibers tested. On the other hand, the SLT contact fibers can be reused between five and ten times. If no tissue effect is noticed anymore, it should be replaced. In case of the use of interstitial laser treatment, the reuse of the applicators seems to be feasible. To lower expenses of laser treatment, it would help if we could reduce the price of the fiber per treatment. The reuse of most side-firing fibers is not recommended, whereas this seems to be possible for the SLT contact system and the interstitial applicators.

Costs

Many issues are important regarding the costs of two procedures. Besides the cost of the procedure, any resulting complications, and the reoperation rate should be included. Also issues such as time lost from work are important but difficult to study. Moreover the costs involved in the purchase of a laser system, the devices used, room power requirements, and safety training of personnel involved in using the laser need to be considered as well. Also the costs may vary from institution to institution and from country to country.

Reducing the number of hospital days is obviously helpful but may not have a great impact on the total hospital cost. Indeed the fibers are still expensive, often costing the equivalent of the room charge for 1 or more days in the hospital. If more than one fiber is required, any hospitalisation cost benefit of the laser procedure could be quickly negated. A reusable device provides significant savings, depending on the durability and the number of times it can be reused. Costs could even be reduced significantly if general or regional anesthesia is not required. Laser treatment using intravenous sedation and a perineal block has been used successfully performed.[50] In our department, we have some experience in performing interstitial laser treatments under a peri-prostatic block. Indeed the vast majority of the patients tolerates this approach very well, and thus we are extending our initial experience.

We think that the costs of laser treatment and TURP seem more or less comparable. Moreover cost analysis is very complex and many issues in addition to simple hospitalisation costs must also be considered. Therefore, we may conclude that currently no final answer is available whether laser treatment is more cost effective than TURP.

Perspectives

Urologists are traditionally in favor of utilising newer forms of therapeutic energy in clinical practice. Specially benign diseases of the prostate may be the first clinical entities where patients may actually profit from these advances. Within the last years, Nd:YAG laser prostatectomy has become a popular treatment alternative for the management of bladder outlet obstruction due to benign prostatic hyperplasia.

Given time, patients can be expected to achieve excellent voiding outcomes following laser prostatectomy, whether measured by objective flow rates and postvoiding residual urine volumes or determined by subjective assessment of symptom score improvement and postoperative patient satisfaction. Overall efficacy has been shown to be comparable and often indistinguishable from electrocautery resection by multiple investigators world-wide. Not only is this procedure efficacious, but increasing numbers of patients with follow up periods of 3 and 4 years or longer are now demonstrating the long-term durability of laser prostatectomy which appears not significantly different from electrocautery resection.

However, laser prostatectomy also has its disadvantages. First of all, a somewhat confusing array of laser fibers, laser beam configurations, and operative techniques are being offered to the urological community. Which type of applicator to use is a fundamental question and depends on the intended immediate laser effect, the morbidity caused, the efficacy, and last but not least the costs. A detailed discussion of basic principles and technical aspects is beyond the scope of this article, but most 'experts' will agree that the clinical improvements are independent of the type of device used. The major difference between these systems are the ease of use and the morbidity caused. The major drawback of the TULIP system was the difficulty to perform a laser treatment using this device, while a prolonged need for catheterization and persisting irritative voiding complaints was observed. These were the major arguments why most colleagues, although a clinical significant improvement could be documented, refrained from this treatment modality. A similar trend may be noticed regarding the currently used side-firing fiber techniques. Although the results are impressive and retreatment is acceptably low, the morbidity is considerably high. The duration of catheterization is at average 1-2 weeks. Moreover, in almost half of these patients, irritative voiding may occur. The major advantages of the SLT contact system and the interstitial laser approach are obvious. In case of the use of SLT contact probes, an immediate cavitation is created following vaporisation of the adenomatous tissue, thus resulting in a decreased need for catheterization. However irritative complaints still may be observed in a significant number of patients during the first weeks after treatment. In case of the interstitial laser coagulation approach, still a prolonged catheterization time can be observed; however, by preserving the urethral mucosa the morbidity is minimal.

How to overcome the current shortcomings of laser prostatectomy? To be accepted as an alternative to TURP, a successful early catheter removal within 24h after the visual laser ablation of the prostate, without significant morbidity, is required. Indeed vaporisation appears to allow an earlier removal of catheters and a reduction in postoperative discomfort.[24] However, contact devices are relatively slow and tedious in use and are generally felt to be suitable only for smaller glands. An improved SLT- contact probe (VaporMax) was recently introduced to overcome these problems (Fig.2). In contrast to the MRTL-10 probe, the energy can be delivered at an angle of 90°. In case of the use of the interstitial laser coagulation device, another approach may be recommended to overcome the shortcomings of this treatment. In a recent study by Talja et al, the use of a self-reinforced spiral stent was presented, showing an effective and safe method to prevent postoperative urinary retention after laser prostatectomy.[51]

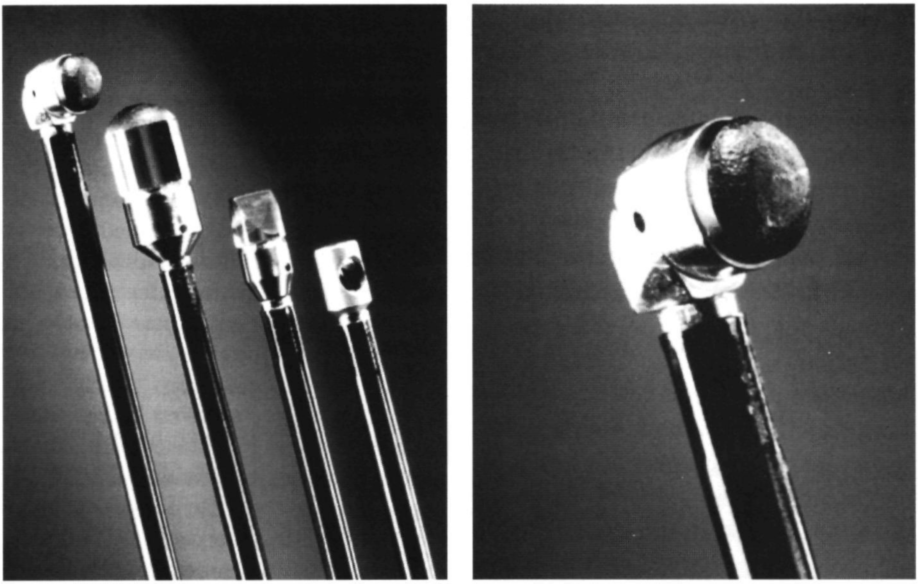


Fig. 2 ***a*** *Different kinds of laser fibertips. From left to right: the VaporMax, the MRTL-10, the chisel (a contact probe for bladder neck incisions), and a side-firing fiber.* ***b*** *VaporMax. The contact probe which delivers the laser energy at an angle of 90 °.*

Finally important issues regarding laser prostatectomy are the reuse of laser fibers and the performance of a treatment under local anaesthesia. Both seem to be within reach of the aforementioned treatment options and should be pursued. Moreover, we need to improve our understanding concerning the laser-tissue interaction. When using a vaporising approach such as the SLT contact system, this understanding is not really necessary because "what you see is what you get". However, in case of the use of all other techniques such an understanding of the mechanisms of action as well as a better guided treatment are mandatory. During every treatment, the optimum intraprostatic temperature should be achieved to obtain the requested result, namely adequate coagulation. The Indigo ILC system is currently evaluated using a so called 'temperature-sensing' system. In order to perform an effective treatment, temperatures should be sufficiently high, but not too high to avoid charring which makes the treatment inefficient and out of control. The optimal temperature for coagulation is estimated to be around 100^{o} C. It is well known that the achieved tissue temperature not only depends on the power input by the treatment device but also by the energy absorption of the tissue. A well perfused area in the prostate will require a higher energy dose to achieve and maintain a certain temperature than a poorly perfused area. Thus is seems logical that each puncture in the prostate may require a different energy input to reach the same predictable volume of coagulation. To overcome this variability caused by the tissue characteristics, a thermosensor is build in the diffuser tip of the fiber of this new interstitial treatment device(Fig.3). During treatment the temperature is monitored continuously, and temperature and power output form a feedback loop which maintains a temperature of 100^{o} C independent of perfusion or any other tissue characteristic.

We may conclude that following the introduction of laser energy to treat patients with benign prostatic enlargement, laser therapy has evolved rapidly. Although the results following side-firing laser treatment are excellent, the morbidity caused seems to be a major drawback. The prolonged need for catheterization can be overcome by using (newly developed) contact laser devices. Another approach to overcome posttreatment retention is the use of temporarily placed prostate stents. Finally interstitial laser applicators provide good results while the posttreatment irritative voiding complaints are only minimal. An ingenious feed back mechanism is being provided to achieve a safe and highly efficient treatment in all patients.

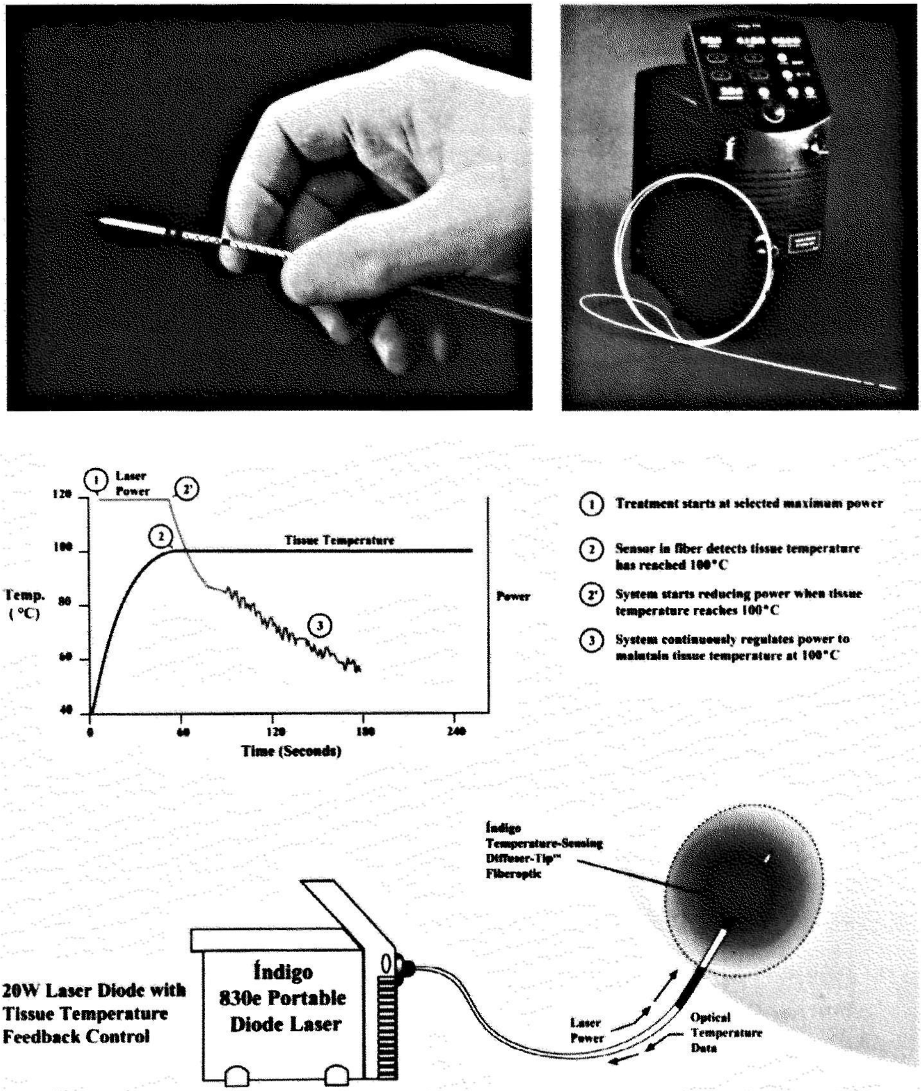


Fig. 3 ***a*** *Interstitial laser fiber with a built-in thermosensor.* ***b*** *Laser source: the Indigo 830 portable diode laser.* **c** *Indigo tissue-adaptive interstitial laser coagulation.*

References

1 Abbou C-C, Payan C, Viens-Bitker C, Richard F, Boccon-Gibod L, Jardin A, Beurton D, Le Duc A, Fermanian J, Thibault P and THE FRENCH BPH HYPERTHERMIA GROUP Transrectal and transurethral hyperthermia versus sham treatment in benign prostatic hyperplasia a double-blind randomized multicentre clinical trial Br J Urol **76** 619, 1995

2 Williams G, White R Experience with the Memotherm permanently implanted prostatic stent Br J Urol **76** 337, 1995

3 Lepor H, Sypherd D, Machi G, Derus J Randomised double-blind study comparing effectiveness of balloon dilation of the prostate and cystoscopy for the treatment of symptomatic benign prostatic hyperplasia J Urol **147** 639, 1992

4 Beisland H, Sander S First clinical experiences on Neodymium-YAG laser irradiation of localised prostatic cancer Scan J Urol Nephrol **20** 113, 1986

5 Shanberg AM, Tansey LA, Baghdassarian R The use of the neodynium YAG laser prostatectomy J Urol **133:** 331A, 1985

6 Kandel LB, Harrison LH, McCullough DL, Woodruff RD, Dyer RD Trans-urethral laser prostatectomy creation of a technique for using the Neodymium Yttrium Aluminium Garnet (YAG) laser in the canine model J Urol **135** 110A, 1986

7 Johnson DE, Levinson AK, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, Wishnow KI Transurethral laser prostatectomy using a right-angle delivery system Lasers Urol Laparosc Gen Surg **1421** 36, 1991

8 Roth RA, Aretz HT Transurethral ultrasound-guided laser induced prostatectomy (TULIP procedure) a canine prostate feasibiltiy study J Urol **146** 1128, 1991

9 Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J Laser ablation of the prostate in patients with benign prostatic hypertrophy Br J Urol **69** 603, 1992

10 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier HA, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy National Human Cooperative Study results J Urol **150** 1607, 1993

11 Puppo P, Perachino M, Ricciotti G Scannapieco G Transurethral ultrasound-guided laser induced prostatectomy Eur Urol **25** 220, 1995

12 de la Rosette JJMCH, Froeling FMJA, Alivizatos G, Debruyne FMJ Laser ablation of the prostate experience with an ultrasound guided technique and a procedure under direct vision Eur Urol **25** 19, 1994

13 Schulze H TULIP transurethral ultrasound-guided laser-induced prostatectomy World J Urol **13** 94, 1995

14 Norris JP, Norris DM, Lee RD Rubenstein MA Visual laser ablation of the prostate clinical experience in 108 patients J Urol **150** 1612, 1993

15 de la Rosette JJMCH te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the ultraline and urolase laser fibers is there any difference World J Urol **13** 98, 1995

16 Kabalin JN Laser prostatectomy performed with a right angle firing neodymium YAG laser fiber at 40 watts power setting J Urol **150** 95, 1993

17 Costello AJ, Lusaya DG, Crowe HR Transurethral laser ablation of the prostate - long term results World J Urol **13** 119, 1995

18 Cowles III RS, Kabalin JN, Childs S, Lepor H, Dixon C, Stein B, Zabbo A A prospective randomized comparison of transurethral resection to visual laser ablation of the prostate for the treatment of benign prostatic hyperplasia Urology **46** 155, 1995

19 Boon TA, van Swol CFP, van Venrooij GEPM, Beerlage HP, Verdaasdonk RM Laser prostatectomy for patients with benign prostatic hyperplasia a prospective randomized study comparing two different techniques using the Prolase-II fiber World J Urol **13** 123, 1995

20 van Swol CFP, Verdaasdonk RM, van Vliet RJ, Molenaar DG, Boon TA Side-firing devices for laser prostatectomy World J Urol **13** 88, 1995

21 Shanberg AM, Sawyer DE, Lee IS, Rodgers LW, Tansey LA, Ahlering T Depth of penetration of the neodymium yttrium- aluminium-garnet laser in the human prostate and clinical results of high-dose laser energy in 50 patients World J Urol **13** 78, 1995

22 de la Rosette JJMCH Laser ablation of the prostate coagulation versus vaporization In Application of Newer Forms of Therapeutic Energy in Urology Editor Michael Marberger, Isis Medical Media Ltd, Oxford, pp 189-197, 1995

23 Narayan P, Tewari A, Aboseif S, Evans C A randomized study comparing visual laser ablation and transurethral evaporation of prostate in the management of benign prostatic hyperplasia J Urol **154** 2083 1995

24 Watson G Contact laser prostatectomy World J Urol **13** 115, 1995

25 Narayan P, Fournier G, Indudhara, Leidick R, Shinohara K, Ingerman A Transurethral evaporation of prostate (TUEP) with Nd YAG laser using a contact free beam technique results in 61 patients with benign prostatic hyperplasia Urology **43** 813, 1994

26 Muschter R, Hofstetter A Technique and results of interstitial laser coagulation World J Urol **13** 109, 1995

27 McNicholas TA, Aslam M, Lynch MJ, O'Donoghue N Interstitial laser coagulation for the treatment of urinary outflow obstruction J Urol **149** 465A, 1993

28 Hoopes JP, Williams JC, Harris RD Ryan TP, Heaney JA, Andrus WS, Rykhus RL, McNicholas TA, Wishnow K Interstitial laser coagulation (ILC) of the canine

prostate with transrectal ultrasound (TRUS) and thermal monitoring J Urol **151** 334A, 1994

29 Muschter R, Perlmutter AP, Hessel S, Hofstetter A Interstitial laser coagulation of benign prostatic hyperplasia three years' experience In Application of Newer Forms of Therapeutic Energy in Urology Editor Michael Marberger, Isis Medical Media Ltd, Oxford, pp179-187, 1995

30 Kabalin JN Editorial laser prostatectomy - what we have accomplished and future directions J Urol **154** 2093, 1995

31 Buckley JF, Ligan V, Paterson P Endoscopic laser ablation of the prostate gland J Urol **151** 229A, 1994

32 Dixon CM A comparison of transurethral prostatectomy with visual laser ablation of the prostate using the urolase right-angle fiber for the treatment of BPH World J Urol **13** 126, 1995

33 Costello AJ, Crowe HR A single institution experience of reflecting laser fibre prostatectomy over four years J Urol **151** 229A, 1994

34 Blaivas JG Multichannel urodynamic studies in men with benign prostatic hyperplasia Urol Clin N Amer **17** 543, 1990

35 Abrams PH, Griffiths DJ The assessment of prostatic obstruction from urodynamic measurements and from residual urine Br J Urol **51** 129, 1979

36 te Slaa E, de Wildt MJAM, Rosier PFWM, Wijkstra H, Debruyne FMJ, de la Rosette JJMCH Urodynamic assessment in the laser treatment of benign prostatic enlargement Br J Urol **76** 604, 1995

37 Cannon A, de Wildt M, Abrams PH, de la Rosette JJMCH Urodynamics and laser prostatectomy World J Urol **13** 134, 1995

38 de Wildt MJAM, te Slaa E, Rosier PFWM, Wijkstra H, Debruyne FMJ, de la Rosette JJMCH Urodynamic results of laser treatment in patients with BPH Can outlet obstruction be relieved J Urol **154** 174, 1995

39 Anson KM, Watson GM Lasers in the treatment of benign prostatic hyperplasia In Puppo P (ed) Contemporary BPH management Monduzzi editore, Bologna, pp 91-101, 1993

40 Mebust WK, Holtgrewe HL, Cockett ATK, Peters PC and writing committee Transurethral prostatectomy Immediate and postoperative complications A cooperative study of 13 participating institutions evaluating 3,885 patients J Urol **141** 243, 1989

41 Holtgrewe HL, Mebust WK, Dowd JB, Cockett ATK, Peters PC, Proctor C Transurethral prostatectomy Practice aspects of the dominant operation in American Urology J Urol **141** 248, 1989

42 Doll HA, Black NA, McPershon K, Flood AB, Williams GB, Smith JC Mortality,

morbidity and complications following transurethral resection of the prostate for Benign Prostatic Hyperthrophy J Urol **147** 1566, 1992

43 Cummings JM, Parra PO. Boullier JA Crawford K, Petrofsky J, Caulfield JJ Evaluation of fluid absorption during laser prostatectomy by breath ethanol techniques J Urol **154** 2080, 1995

44 Bolton DM, Costello A Management of benign prostatic hyperplasia by transurethral laser ablation in patients treated with warfarin anticoagulation J Urol **151** 79, 1994

45 te Slaa E, Mooibroek JJ, de Reijke TM, Karthaus HFM, van Capelle JW, de la Rosette JJMCH Laser treatment of the prostate using the Urolase fiber The dutch experience J Urol **157** 420, 1996

46 Roos NP, Wennberg JE, Malenka DJ, Fisher ES, McPherson K, Anderson TF, Cohen MM, Ramsey E Mortality and reoperation after open and transurethral resection of the prostate for benign prostatic hyperplasia New Engl J Med **320** 1120, 1989

47 Chute CG, Stephenson WP, Guess HA Benign Prostatic Hyperplasia A population-based study Eur Urol **20**(suppl 2) 11, 1991

48 te Slaa E, van Ettergem AF van t Hof CA, Debruyne FMJ, de la Rosette JJMCH Durability of laser fibers World J Urol **13** 83, 1995

49 van Swol CFP, te Slaa E, Verdaasdonk RM, de la Rosette JJMCH, Boon TA Urology **47** 672, 1996

50 Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R Outpatient visual laser-assisted prostatectomy under local anethesia Urology **43** 149 1994

51 Talja M, Tammela T, Petas A, Valimaa, Taari K, Viherkoski F, Tormalà Biodegradable self-reinforced polyglycolic acid spiral stent in prevention of postoperative urinary retention after visual laser ablation of the prostate-laser prostatectomy J Urol **154** 2089, 1995

Addendum

Personal View

It has been many years since Malcolm McPhee called surgical lasers "machines in search of a disease". In urology this remained true until five years ago, when this disease seemed to be benign prostatic obstruction (BPO) as a result of

benign prostatic hyperplasia (BPH). Since the first reports of laser prostatectomies in men published by Costello[1], it became clear that laser treatment of the prostate could indeed replace the transurethral electroresection of the prostate (TURP). Many studies [2-6] reported about the efficacy of laser prostatectomy in the treatment of BPO. In several randomised studies [7-9] the results were almost comparable or even equal to results after TURP. Furthermore the complications, which are well-known after TURP (such as transurethral resection syndrome, bloodtransfusions, clot retention, urethral strictures and incontinence) were only incidental seen after laser prostatectomy. Moreover laser prostatectomy is easier to learn when compared to TURP, and could be performed as an outpatient procedure even under local anaesthesia. This progress of the laser in the treatment of BPO resulted in the statement "laser is here to stay" at the AUA meeting in 1994. These statements were never made for other alternative treatments such as balloon dilatation, hyperthermia, and prostatic stents.

But with more experience and investigations, more data came available revealing that also laser prostatectomy had its drawbacks. In contrast to TURP it will take about 4 to 6 weeks and sometimes up to 3 months after laser treatment before the optimal result is established. Following a TURP procedure, patients will have a good result almost immediately after removal of the indwelling catheter. Furthermore there is a prolonged catheterization duration, irritative voiding complaints for 4 to 6 weeks and a higher rate of urinary tract infections following laser treatment of the prostate. To overcome

these problems several techniques and different types of fibers were developed resulting in contact tips for direct vaporisation and fibers for interstitial laser coagulation. It seemed that each new technique resulted in solving one problem and creating another. Contact tips for vaporisation appeared to create a direct cavity in the prostatic urethra and as a result catheterization duration was shortened, but the procedure is tediously slow and at this moment only suitable for small prostates. The same holds true for the interstitial laser coagulation, which leaves the mucosa of the prostatic urethra intact and as a result irritative voiding symptoms are less. But also this technique has a long catheterization duration. Thus at this moment laser treatment of the prostate is by no means the optimal treatment for BPO. This statement is supported by the fact that at this moment there is no optimal laser procedure, reflected by the numerous different laser devices and techniques which are available today. Also the ongoing development of new fibers, new treatment methods and the use of different laser sources clearly shows that still much needs to be done in order to develop this laser technology. Furthermore other new technologies as thermotherapy, transurethral needle ablation (TUNA), high intensity focused ultrasound (HIFU) and electrosurgical vaporisation are arising at the horizon. On the other hand we have to acknowledge that there is only five years of experience with laser treatment of the prostate. Whereas in the beginning of the TURP-era (1926) there was a mortality rate of 25 % and it took about 40 years for the TURP to become the golden standard.
At the moment it is my strong feeling that there is no laser procedure which could replace the TURP as golden standard in the treatment of BPO. But that does not mean that there is no place at all for lasers. For example patients with cardiac diseases and/or who are using anticoagulant drugs have a high risk of developing complications during or after TURP. Laser treatment of the prostate is an almost bloodless procedure with no fluid resorption during the procedure. For these cases preferably laser treatment may be recommended.
Because laser treatment of the prostate is still a developing technology it is at

this moment difficult to advise urologists, who are interested in performing laser prostatectomies, which laser source, type of fiber(s) or technique they should use. Maybe combining different technologies of laser prostatectomies will be the final solution. On the other hand laser experts seem to return to resection of prostatic tissue, using the laser as a cutting knife.[10] Indeed the early results are again very promising but more experience with this technique is needed to judge its place in the treatment of BPO.

Concerning these developments, urologists may ask themselves if it is wise to start at all with laser prostatectomies at this moment. Maybe it is better to just wait for the research centers to come with a more advanced laser procedure or an other alternative for TURP.

References

1 Costello AJ, Bowsher WG, Bolton DM, Braslis KG, Burt J Laser ablation of the prostate in patients with benign prostatic hypertrophy Br J Urol **69** 603, 1992

2 McCullough DL, Roth RA, Babayan RK, Gordon JO, Reese JH, Crawford ED, Fuselier A, Smith JA, Murchison RJ, Kaye KW Transurethral ultrasound-guided laser-induced prostatectomy National Human Cooperative Study Results J Urol **150** 1607, 1993

3 Kabalin JN Laser prostatectomy performed with a right angled firing neodynium YAG laser fiber at 40 Watts power setting J Urol **150** 95, 1993

4 Norris JP, Norris DM, Lee RD, Rubenstein MA Visual Laser Ablation of the Prostate Clinical Experience in 108 Patients J Urol **150** 1612, 1993

5 Leach GE, Sirls L, Ganabathi K, Roskamp D, Dmochowski R Outpatient Visual Laser-Assisted Prostatectomy under Local Anesthesia Urology **43** 149, 1994

6 de la Rosette JJMCH, te Slaa E, de Wildt MJAM, Debruyne FMJ Experience with the ultraline and urolase laser fibers is there any difference World J Urol **13** 98, 1995

7 Cowles III RS, Kabalin JN, Childs S, Lepor H, Dixon C, Stein B, Zabbo A A prospective randomized comparison of transurethral resection to visual laser ablation of the prostate for the treatment of benign prostatic hyperplasia Urology **46** 155, 1995

8 Kabalin JN, Gill HS, Bite G Wolfe V Comparative study of laser versus electrocautery prostatic resection 18-month followup with complex urodynamic assessment J Urol **153** 94, 1995

9 Dixon C A comparison of transurethral prostatectomy with visual laser ablation of the prostate using the Urolase right-angle fiber for the treatment of BPH World J Urol **13** 126, 1995

10 Fraundorfer MR, Gilling PJ, Kabalin JN The Holmium Laser in the treatment of Benign Prostatic Hyperplasia J Urol **155** 318A, 1996

Summary

Summary

The use of heat, whatever the source, be it microwaves, high intensity focused ultrasound, radiofrequency or laser light, to treat benign prostatic hyperplasia (BPH) has emerged as the main challenge to the "gold standards" being transurethral resection of the prostate and open prostatectomy. Although these "gold standards" proved to be safe and effective, the morbidity and costs involved in the treatment of BPH were the main reasons for the search for alternative treatments.

This thesis reports on one of these new heat treatments in BPH: laser prostatectomy. The laser fibers were subject of investigations, furthermore efficacy and morbidity of the use of laser light on the prostate were investigated in several studies.

Laser energy is partially absorbed by the prostatic tissue and then converted to heat which produces thermal damage. The amount of energy absorbed by the prostatic tissue is not the same as the amount provided by the laser source. This depends on a number of variables, one of those is loss of transmission in the laser fiber and the deflecting mechanism. During a laser procedure, changes in the laser fiber may occur due to deterioration of parts of the laser fiber that transmit or deflect the laser light, resulting in a loss of transmission.

In the first part of **chapter 2** transmission loss is demonstrated in different types of side firing laser devices following a laser procedure. Transmission measurements were performed in a laboratory setting. Visual inspection of the fiber tips appeared to show only a correlation with transmission loss for one specific type of fiber. There was no correlation between the total amount of kJoules provided by the laser source and transmission loss of the fiber. In the second part of chapter 2 the use of a power meter provided more insight because transmission measurements could now be performed under clinical conditions, that is, under water with high power input. Eight types of side firing devices were investigated prior to treatment. These fibers were compared to the results of measurements of a bare fiber at 60 W. input. Three types of fibers were tested before and after a laser procedure. The

transmission strongly varies between new fibers and also between different samples of one fiber during clinical use. A significant correlation between visual inspection and transmission was noted only for a specific type of fiber, however the situation for one particular fiber may be different. Therefore, power measurements during clinical treatment will contribute to a more controlled procedure and to a better comparison of clinical laser postatectomy studies. In the third part of chapter 2 the influence of the transmission loss of laser fibers on clinical outcome was investigated. Three types of laser fibers were studied. A relation between the amount of transmission loss and the clinical outcome could not be found for all three types of fibers. The fibers were only measured at the end of the procedure and compared to the transmission of a new fiber, of the same type. However, loss of transmission is not a linear process and therefore this can be a reason for not finding a relation with clinical outcome. Furthermore the number of non responders in this study was very small, making it very difficult to find any significant relation.

The clinical results are discussed in **chapter 3**. The first part presents a study that shows significant improvement in objective and subjective parameters for both side firing devices investigated. No statistically significant difference was found in the clinical outcome of laser prostatectomies performed with both devices. In the second part, a multicenter study is presented with data of 233 patients from 5 centers where laser prostatectomies were performed with one type of side firing laser device. Although there were some differences in clinical outcome, all centers showed significant improvement in clinical outcome parameters after laser prostatectomy. Furthermore it was clear from this study that morbidity after a laser procedure was significant, with irritative voiding complaints for 4 to 6 weeks in up to 50% of all patients and urinary tract infections in 21.1%.

Although the improvements in uroflow parameters are significant, the desobstructive abilities of laser prostatectomy were questioned. To investigate these abilities urodynamic investigations are needed. In **chapter 4** the results of advanced urodynamics before and 6 months after laser prostatectomy are presented. Before laser treatment 65 to 90% of the patients were considered to be obstructed, depending on what obstruction parameter was used. After treatment 5 to 18% were still considered to be obstructed. A comparison of the outcome between minimally and severely obstructed patients before treatment showed comparable improvements, concerning symptom score and uroflowmetry parameters.

Chapter 5 presents the morbidity of laser prostatectomy. In the first part the incidence of urinary tract infections tended to be, although not significantly, lower when perioperative antibiotics were used. There seemed to be a relation between the duration of postoperative catheterization and the risk of developing urinary tract infection. A relation between urinary tract infections and irritative voiding complaints, however, could not be found. The second part reports on the quality of life. Data of 103 patients were evaluated and showed a significant improvement in quality of life after laser prostatectomy. No relation was found between the maximum flow and the quality of life.

Finally, **chapter 6** gives a review of laser prostatectomy and future developments especially in fiber technology, that might contribute to maintain the achieved objective and subjective improvement with a lower postoperative morbidity.

Samenvatting

Samenvatting

De gouden standaard in de behandeling van benigne prostaat hyperplasie (BPH) is de chirurgische verwijdering van het prostaatadenoom via transurethrale weg dan wel door middel van een open prostatectomie. Deze ingrepen hebben gedurende de laatste decennia bewezen veilig en effectief te zijn, echter de morbiditeit van deze ingrepen en de aanzienlijke kosten van de behandeling van BPH voor de gezondheidszorg hebben geleid tot de ontwikkeling van alternatieve behandelingsmethoden.

Dit proefschrift beschrijft één van deze nieuwe behandelingen voor BPH, te weten de laser prostatectomie. Naast het verrichten van basaal onderzoek van de laser fibers, zijn ook de effectiviteit en de morbiditeit van de laser behandeling van de prostaat onderzocht in verschillende studies.

Laser energie wordt maar gedeeltelijk door het prostaatweefsel geabsorbeerd en vervolgens omgezet in warmte. Hierdoor kan thermische schade van het weefsel ontstaan. De hoeveelheid energie die door de prostaat wordt geabsorbeerd is niet gelijk aan de hoeveelheid die door de laserbron wordt geleverd. Eén van de oorzaken is het verlies van transmissie in de laser fiber en in het reflectie mechanisme in de tip van de fiber. Onderdelen van de laser fiber welke het laserlicht transporteren of afbuigen, kunnen tijdens de laser behandeling verontreinigt raken. Hierdoor ontstaan veranderingen in de fiber en fibertip, waardoor toename in transmissieverlies kan worden veroorzaakt.

In het **tweede hoofdstuk** wordt het verlies van transmissie in twee verschillende types zijwaarts-schijnende laserfibers gepresenteerd, nadat deze zijn gebruikt voor een laserbehandeling van de prostaat. De transmissie metingen werden verricht onder niet klinische omstandigheden. Er leek alleen voor één type laserfiber een correlatie met het transmissieverlies te bestaan. Er bestond geen relatie tussen de totaal geleverde hoeveelheid kJoules en het verlies in transmissie van een laserfiber. In het tweede deel van hoofdstuk 2 wordt de power meter geïntroduceerd waardoor het mogelijk wordt om transmissie metingen te verrichten onder klinische omstandigheden, dus onder water en met een hoge power input. Acht soorten, nieuwe, zijwaarts-schijnende laserfibers werden onderzocht. De resultaten van de transmissie metingen werden vergeleken bij een input van 60 Watt met die van een fiber, die geen tip heeft met een afbuigmechanisme zodat de invloed van zo'n tip, die voor alle acht onderzochte fibers anders is, kon worden vastgelegd. Drie soorten laserfibers werden onderzocht voor en na een laserbehandeling. De transmissie varieerde sterk tussen de 8 nieuwe laserfibers en ook tussen verschillende fibers van één en dezelfde soort tijdens een laserbehandeling. Er bestaat een significante relatie voor één type laser fiber tussen de visuele beoordeling van de fibertip en de mate van transmissieverlies. Echter over één aparte laser fiber kan aan de hand van het visuele aspect van de fibertip, niets over de mate van transmissieverlies worden gezegd. Transmissiemetingen tijdens een laserbehandeling dragen bij tot een betere controle van de laserprocedure en het beter vergelijkbaar maken van de resultaten van studies over laserbehandeling van de prostaat. Het laatste deel van hoofdstuk 2 beschrijft de invloed van het transmissieverlies van laserfibers op de klinische resultaten van een laserbehandeling. Drie verschillende soorten laserfibers werden onderzocht en voor alle drie bestond er geen verband tussen de mate van transmissieverlies en de klinische resultaten. In deze studie werden de transmissiemetingen alleen aan het einde van een laserbehandeling verricht en vervolgens vergeleken met de transmissie van een nieuwe laserfiber van hetzelfde type. Het feit dat transmissieverlies van een laserfiber tijdens de laserbehandeling geen lineair proces is, kan een reden zijn dat er geen verband met de klinische resultaten werd gevonden. Daarnaast was het aantal nonresponders in deze studie erg klein, zodat een significante relatie sowieso moeilijk te vinden is.

Hoofdstuk 3 beschrijft de klinische resultaten. In het eerste deel wordt een studie beschreven waarin laserbehandeling van de prostaat met twee verschillende zijwaarts-schijnende laserfibers was onderzocht. Er bestond een significante verbetering in objectieve en subjectieve parameters na de laserbehandeling. Er was geen verschil tussen de twee onderzochte laserfibers. Het tweede deel van dit hoofdstuk beschrijft een multicentrische studie van 233 patiënten uit 5 centra. In alle centra werd de laserbehandeling verricht met eenzelfde type zijwaarts-schijnende laserfiber. Ondanks enkele verschillen in klinische resultaten tussen de centra, was er een significante verbetering in subjectieve en objectieve parameters na laserbehandeling voor alle centra. De morbiditeit van de laserbehandeling was significant, met irritatieve mictieklachten gedurende 4 tot 6 weken postoperatief in bijna 50% van de patiënten en urineweginfecties in 21,1%.

Ondanks duidelijke verbetering in uroflowmetrie parameters, is urodynamisch onderzoek met "pressure-flow" analyse noodzakelijk voor het aantonen van desobstructieve mogelijkheden van een laserbehandeling van de prostaat. In **hoofdstuk 4** worden de resultaten gepresenteerd van geavanceerd urodynamisch onderzoek verricht voor en 6 maanden na een laserbehandeling. Voor de behandeling waren, afhankelijk van de gebruikte parameters, 65 tot 90% van de patiënten urodynamisch obstructief. Na laserbehandeling van de prostaat was dit nog maar 5 tot 18% van de patiënten. Verder bleek dat patiënten die voor de laserbehandeling minimaal obstructief waren, vergelijkbare verbetering in uroflowmetrie parameters en symptomscore hadden, als patiënten die tevoren ernstig obstructief waren.

Morbiditeit na een laserbehandeling wordt beschreven in **hoofdstuk 5**. De incidentie van urineweginfecties wordt verminderd, echter niet significant, door het gebruik van perioperatieve antibiotica. In deze studie bestaat er een verband tussen de duur van postoperatieve catheterisatie en de kans op het ontwikkelen van een urineweginfectie. Er bestond geen relatie tussen de irritatieve mictieklachten en de aanwezigheid van een urineweginfectie. Kwaliteit van leven voor en na laserbehandeling werd onderzocht in 103 patiënten. Er was een duidelijke verbetering in kwaliteit van leven als gevolg van de laserbehandeling. Er werd in deze studie geen verband gevonden tussen de maximale flowsnelheid en kwaliteit van leven.

In **hoofdstuk 6** wordt een overzicht gegeven van de literatuur van laserbehandelingen van de prostaat. Tevens worden nieuwe ontwikkelingen, vooral in fibertechnologie, beschreven welke in de toekomst mogelijk kunnen bijdragen tot vermindering van de morbiditeit, als gevolg van een laserbehandeling van de prostaat, zonder de effectiviteit te beïnvloeden.

Dankwoord

Dit proefschrift zou er niet zijn, zonder de inspanningen van vele anderen. Zonder iemand van hen tekort te willen doen wil ik een aantal personen afzonderlijk noemen.

Allereerst mijn promotor Prof. Dr. F.M.J. Debruyne, die mij de gelegenheid heeft geboden om tijdens mijn opleiding dit onderzoek, waarvan in het begin nog niet duidelijk was of dit onderwerp geschikt zou zijn voor een promotie, te verrichten.

Mijn co-promotor Dr. J.J.M.C.H. de la Rosette, zoals voor velen, ook voor mij de belangrijkste persoon bij de totstandkoming van dit proefschrift. Beste Jean, zonder jouw stimulerende woorden en schoppen onder mijn "geestelijke achterwerk" zou ik nooit zover gekomen zijn. Door jouw enorme geestdrift en humor vond ik het zeer inspirerend en aangenaam om met jou samen te werken, ook al "kneep je al je slaven volledig uit als een citroen".

Dr. H.J.M. Karthaus: één van de pioniers op het gebied van laser behandeling van de prostaat in Nederland. Beste Herbert, jij stimuleerde mij om te starten met onderzoek op het gebied van lasers in BPH als eventuele basis voor een promotieonderzoek. Vooral nu na het voltooien van dit boekje ben ik je daar zeer dankbaar voor.

Dr. M.J.A.M. de Wildt; beste Michel, jou wil ik bedanken voor het eeuwige uitleggen van computerprogramma's zodat ik uiteindelijk zelf databases, grafieken en dia's kon maken. Tevens dank ik je voor al het urodynamisch onderzoek hetgeen je hebt verricht bij onder andere bijna alle laser patiënten. Naast het overbrengen van het computervirus heb je mij toch ook enigszins besmet met het toentertijd nog bekende "Prince"-virus.

Dr. Tom Boon en de ingenieurs Christiaan van Swol en Ruud Verdaasdonk van het Academisch Ziekenhuis te Utrecht ben ik zeer erkentelijk voor de prettige samenwerking hetgeen geleid heeft tot een tweetal gezamenlijke artikelen.

De ingenieurs A.F. van Ettergem en C.A. van 't Hof van de Katholieke universiteit Nijmegen wil ik bedanken voor het realiseren van het eerste

meetinstrument waarmee we de laserfibers hebben doorgemeten.
Voorts gaat mijn dank uit naar W. Doesburg, R. de Graaf en J.C.M. Hendriks van het MSA voor de statistische bewerking.
De leden van het Trialbureau wil ik bedanken voor de hulp bij het verrichten van de(r)gelijk klinisch onderzoek.
Vele woorden hebben hier gestaan, maar geen enkel voldeed.
Pa, Ma, Pien, Laura, Daphne, Pim, Mauk ....bedankt.

Curriculum vitae

De schrijver van dit proefschrift werd geboren op 11 november 1959 te 's-Gravenhage. Na het voorbereidend wetenschappelijk onderwijs (V.W.O.) aan de Dalton scholengemeenschap te 's-Gravenhage werd in 1978 de studie Geneeskunde aangevangen aan de Erasmus Universiteit te Rotterdam. Van maart 1987 tot en met augustus 1989 was hij werkzaam als Agnio (arts geneeskundige niet in opleiding) op de afdeling Urologie van het Reinier de Graaf Gasthuis te Delft. In dit zelfde ziekenhuis was hij van september 1989 tot en met juni 1992 werkzaam op de afdeling algemene heelkunde in het kader van de vooropleiding chirurgie (opleider: Dr. W.B.J. Jansen). Van juli 1992 tot en met december 1993 werd het perifere deel van de opleiding urologie doorlopen in het Canisius Wilhelmina Ziekenhuis te Nijmegen (opleider: Dr. H.F.M. Karthaus). Tijdens deze periode werd reeds onderzoek verricht naar de resultaten van laser behandeling van de prostaat, hetgeen later de opstap bleek voor het begin van een promotie-onderzoek. Vervolgens was hij van januari 1994 tot en met juni 1996 werkzaam op de afdeling urologie van het Academisch Ziekenhuis Sint Radboud te Nijmegen (Hoofd: Prof. Dr. F.M.J. Debruyne). Vanaf 1994 werd naast de opleiding onderzoek verricht, onder leiding van Dr. J.J.M.C.H. de la Rosette, leidend tot dit proefschrift.

Sinds 1 juli 1996 is hij werkzaam als uroloog in de urologen-maatschap Zwolle/Meppel.

Hij is getrouwd met Pien Hage en vader van vier kinderen: Laura, Daphne, Pim en Mauk.

Stellingen behorende bij het proefschrift

Laser prostatectomy in the treatment of benign prostatic enlargement

door

Eduard te Slaa

Nijmegen, 27 mei 1997

I. Ondanks verschil in bundelkarakteristieken en afbuigmechanisme is er geen verschil in de klinische resultaten na laser behandeling van de prostaat met diverse side-firing laser fibers. (*dit proefschrift*)

II. Laser behandeling van de prostaat met side-firing laser fibers veroorzaakt urodynamisch bewezen desobstructie bij het merendeel van de behandelde patienten. (*dit proefschrift*)

III. Laser behandeling van de prostaat met side-firing laser fibers is niet zonder morbiditeit. (*dit proefschrift*)

IV. Een normaal aspect van de fibertip van een side-firing laser fiber, gedurende een laser behandeling, betekent niet dat er geen tranmissie-verlies aanwezig is. (*dit proefschrift*)

V. Bij LUTS is de hinder die een patient van een symptoom heeft (bother-score) belangrijker dan het symptoom zelf. (*dit proefschrift*)

VI. Pas als de morbiditeit na laserbehandeling van de prostaat afgenomen is en de lange termijn resultaten goed blijven, kan de TURP van zijn troon gestoten worden. (*dit proefschrift*)

VII. Verbetering van symptoom scores is niet gerelateerd aan verbetering van objectieve parameters na een laser behandeling van de prostaat met side-firing laser fibers. (*dit proefschrift*)

VIII. Niet alle fracturen dienen door een algemeen of orthopaedisch chirurg te worden behandeld; een enkele keer komt er een uroloog aan te pas.

IX. Bij het overwegen van een penisverlenging ter vergroting van het mannelijk ego, moet men zich wel bedenken dat in dezelfde prijsklasse een kleine sportieve oldtimer kan worden aangeschaft, hetgeen een zelfde invloed kan hebben.

X. Gezien de huidige ontwikkelingen in de voetbalsupporterswereld wordt de uitspraak "voetbal is oorlog" wel erg letterlijk genomen.

ISBN 90 9010565 4